Potential Impacts on Birds in the Mackenzie Valley from Pipeline Clearings for the Mackenzie Gas Project

**John M. Cooper, Matthew Wheatley, Paul A. Chytyk,
Aaron Deans, Carmen Holschuh and
Suzanne M. Beauchesne**

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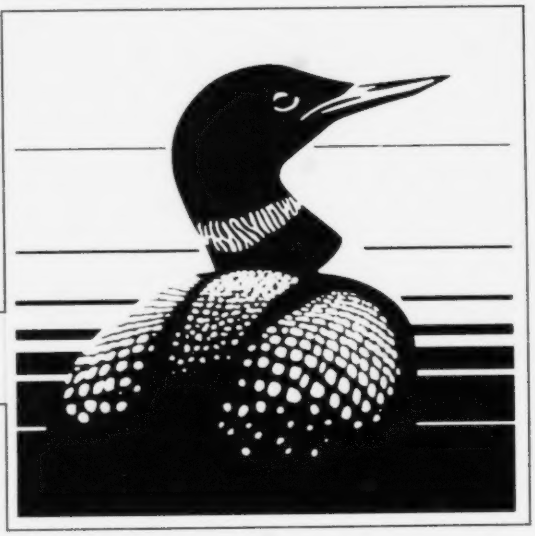

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POTENTIAL IMPACTS ON BIRDS IN THE MACKENZIE VALLEY FROM PIPELINE CLEARINGS FOR THE MACKENZIE GAS PROJECT

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ABSTRACT

The Mackenzie Valley Gas Project proposes to build a 1,220 km pipeline to transport liquid natural gas from Inuvik to a southern terminus in northern Alberta. The proposed pipeline route will follow an existing pipeline corridor for about 500 km, more or less, from Inuvik to Norman Wells, then follow a new alignment for about 800 km, more or less, from Norman Wells to Alberta.

Impacts to birds from an expanded and new pipeline corridor were expected and studies were initiated to estimate impacts. In 2004, breeding bird spot map surveys were conducted at two study areas, Norman Wells and Fort Simpson. These two study areas were chosen to represent certain segments of the Mackenzie Valley, Norman Wells representing a central portion of the pipeline route and Fort Simpson representing a southern portion. Twenty 10 ha plots were established, 12 at Fort Simpson and 8 at Norman Wells. Plots represented typical habitats in both study areas. Vegetation characteristics were measured for each plot. Plots were surveyed 10 times each in June 2004 and all territorial birds were recorded on field maps. Data were later digitized into GIS systems and analyzed to quantify habitat and breeding bird territories. Data were specifically analyzed to determine densities of breeding birds in each habitat and species/habitat associations.

Landsat GIS coverages were used to quantify habitats across a 200 km long (100 km south and north of both Norman Wells and Fort Simpson) by 50 m wide pipeline corridor at each study area. Breeding bird densities at each study area were then used to extrapolate densities across similar habitats along the length of the 200 km corridor segment. Potential losses of habitat and breeding birds were then estimated for the 200 km long segment.

It was estimated that 1812 breeding bird pairs of 49 species and 2069 ha of habitat would be lost from the combined 400 km of pipeline corridor. A loss of 4.53 breeding landbird pairs/km of pipeline was estimated. Almost all of the estimated losses of birds were of songbirds (98.7% at Norman Wells, 92% at Fort Simpson). Sparrows (36.1%), warblers (35.8%) and thrushes (13.6%) were estimated to lose the largest numbers of breeding birds. Losses of individual species of breeding bird depended on densities in each habitat and amount of habitat lost to clearing. Largest estimated losses for breeding birds were Chipping Sparrow (187 pairs), Tennessee Warbler (175), Yellow-rumped Warbler (135), Lincoln's Sparrow (119), Swainson's Thrush (115), Palm Warbler (103), Dark-eyed Junco (94), Ruby-crowned Kinglet (63), Swamp Sparrow (61), Yellow-bellied Sapsucker (54), Ovenbird (54) and Clay-colored Sparrow (53). Largest amounts of habitat estimated to be lost were black spruce closed (664 ha), black spruce open (498 ha), mixed forest (174 ha), low shrubland (150 ha), white spruce (141 ha), spruce lichen boreal forest (89 ha), fir regen/low shrubland (84 ha), jackpine (61 ha, and tall shrubland (58 ha).

Bird/habitat associations were determined by detrended correspondence analysis. At Fort Simpson shrubland bird communities were defined most by White-throated Sparrow, Lincoln's Sparrow, Swamp Sparrow, Clay-colored Sparrow, LeConte's Sparrow and

Common Yellowthroat. Black spruce communities were defined most by Dark-eyed Junco, Gray Jay, Three-toed Woodpecker, Ruby-crowned Kinglet, Chipping Sparrow and Yellow-rumped Warbler. Deciduous communities were defined mainly by Warbling Vireo, Least Flycatcher and Red-eyed Vireo. At Norman Wells, burn areas were defined by Northern Waterthrush, Lesser Yellowlegs, Clay-colored Sparrow, Alder Flycatcher and Savannah Sparrow. Black spruce communities were defined by Chipping Sparrow, Hermit Thrush, Blackpoll Warbler, Dark-eyed Junco and Ruby-crowned Kinglet. Deciduous communities were defined by Black-and-white Warbler, Warbling Vireo, and Yellow-rumped Warbler. Mixed-spruce sites were defined by Tennessee Warbler, Swainson's Thrush and Magnolia Warbler.

Additional data sets were analyzed to assess whether spot map data from 2004 represented a typical year. These data sets included breeding bird surveys (BBS) from 1989-2003 from Norman Wells, Fort Simpson and Fort Liard, EIA reports from the 1970s related to the Arctic gasline in the Mackenzie Valley, and NWT checklist data on file with Canadian Wildlife Service in Yellowknife. BBS data suggested that most species detected during spot map surveys were detected at rates that appeared typical. Although differences in data collection techniques confound results, historical data from the 1970s suggest that species diversity was similar in some habitats, some new species were found in 2004, but overall densities may be lower. Checklist data revealed 269 species have been documented in the Mackenzie Valley, 75 of which were detected during 2004 spot map surveys.

Issues related to adaptive landscape management, retention harvesting strategies along the pipeline corridor, edge effects on birds, bird community responses, ecological indicators and considerations for future landscape-level development are discussed. Recommendations for future studies and approaches related to potential impacts of the pipeline on boreal ecosystems are made.

Conclusions and recommendations contained in this report are those of the author's alone. Neither are necessarily the conclusion or recommendations that Environment Canada or its employees endorse or agree to.

RÉSUMÉ

Le projet gazier de la vallée du Mackenzie prévoit la construction d'un gazoduc de 1220 km destiné au transport du gaz naturel liquide vers le sud depuis Inuvik jusqu'à un terminal situé dans le nord de l'Alberta. Le parcours proposé suivra un corridor pipelinier existant sur environ 500 km entre Inuvik et Norman Wells pour ensuite prendre une autre direction sur environ 800 km entre Norman Wells et le terminal albertain.

Comme on s'attend à ce que l'expansion du tronçon pipelinier existant et la création du nouveau tronçon aient des répercussions sur les oiseaux, on a entrepris des études visant à estimer ces dernières. En 2004, on a réalisé des relevés des oiseaux nicheurs par la méthode des plans quadrillés dans deux zones d'étude représentatives de certains segments de la vallée du Mackenzie, soit Norman Wells, pour la portion centrale du parcours pipelinier, et Fort Simpson, pour la portion méridionale. On a établi 20 parcelles de 10 ha, soit douze à Fort Simpson et huit à Norman Wells. Les deux séries de parcelles étaient représentatives des milieux typiques des deux zones d'étude. Les caractéristiques de la végétation ont été mesurées dans chaque parcelle. Les parcelles ont chacune fait l'objet de dix relevés en juin 2004, et tous les oiseaux territoriaux ont été notés sur les cartes de terrain. Les données ont ensuite été numérisées dans des SIG, puis analysées pour quantifier l'habitat et les territoires des oiseaux nicheurs. Les données ont été analysées par espèce pour déterminer les densités des oiseaux nicheurs dans chaque milieu de même que les associations espèces-milieux.

Des couvertures SIG Landsat ont été utilisées pour quantifier les milieux dans les deux tronçons pipeliniers de 200 km de long (100 km au sud et au nord de Norman Wells et de Fort Simpson) par 50 m de large. À partir des densités d'oiseaux nicheurs mesurées dans chaque zone d'étude, on a ensuite extrapolé les densités par type de milieu sur l'ensemble de chacun des deux tronçons de 200 km. On a pu ainsi estimer les pertes potentielles d'habitat et d'oiseaux nicheurs pour les deux segments de 200 km.

On a estimé que 1812 couples d'oiseaux nicheurs de 49 espèces et 2069 ha d'habitat seraient perdus par suite de l'aménagement des 400 km de corridor pipelinier couverts par l'étude. Une perte de 4,53 couples nicheurs d'oiseaux terrestres/km de gazoduc a été estimée. La presque totalité des pertes estimées tombe dans le groupe des oiseaux chanteurs (98,7 % à Norman Wells, 92 % à Fort Simpson). On a estimé que les plus fortes pertes de couples nicheurs se produiraient chez les bruants (36,1 %), les parulines (35,8 %) et les grives (13,6 %). Les pertes estimées par espèce de couples nicheurs étaient fonction de la densité de chacune des espèces dans chaque milieu et de la quantité d'habitat perdue par suite des travaux d'aménagement pipelinier. Les espèces d'oiseaux nicheurs les plus fortement touchées seraient les suivantes : Bruant familier (perte estimative de 187 couples), Paruline obscure (175), Paruline à croupion jaune (135), Bruant de Lincoln (119), Grive à dos olive (115), Paruline à couronne rousse (103), Junco ardoisé (94), Roitelet à couronne rubis (63), Bruant des marais (61), Pic maculé (54), Paruline couronnée (54) et Bruant des plaines (53). Les types de milieux les plus fortement touchés seraient les suivants : pessière noire fermée (perte estimative de 664 ha), pessière noire ouverte (498 ha), forêt mélangée (174 ha), arbustaie basse

(150 ha), pessière blanche (141 ha), pessière boréale à lichens (89 ha), sapinière en régénération/arbustaie basse (84 ha), pessière grise (61 ha) et arbustaie haute (58 ha).

Les associations oiseaux-milieux ont été déterminées au moyen d'une analyse factorielle des correspondances détendancée. À Fort Simpson, les communautés aviennes d'arbustaie se caractérisaient principalement par le Bruant à gorge blanche, le Bruant de Lincoln, le Bruant des marais, le Bruant des plaines, le Bruant de Le Conte et la Paruline masquée. Les communautés de pessière noire se caractérisaient principalement par le Junco ardoisé, le Mésangeai du Canada, le Pic à dos rayé, le Roitelet à couronne rubis le Bruant familier et la Paruline à croupion jaune. Les communautés des peuplements de feuillus se caractérisaient principalement par le Viréo mélodieux, le Moucherolle tchébec et le Viréo aux yeux rouges. À Norman Wells, les communautés de brûlis étaient caractérisées par la Paruline des ruisseaux, le Petit chevalier, le Bruant des plaines, le Moucherolle des aulnes et le Bruant des prés. Les communautés de pessière noire étaient caractérisées par le Bruant familier, la Grive solitaire, la Paruline rayée, le Junco ardoisé et le Roitelet à couronne rubis. Les communautés des peuplements de feuillus étaient caractérisées par la Paruline noir et blanc, le Viréo mélodieux et la Paruline à croupion jaune. Les communautés de pessière mélangée étaient caractérisées par la Paruline obscure, la Grive à dos olive et la Paruline à tête cendrée.

On a analysé d'autres ensembles de données pour établir si les données des plans quadrillés de 2004 étaient représentatives d'une année typique. Ces ensembles de données sont les suivants : données des relevés des oiseaux nicheurs (BBS -*Beeding Bird Survey*) de 1989 à 2003 pour Norman Wells, Fort Simpson et Fort Liard; données des études d'impact relatives au gazoduc arctique réalisées dans les années 1970 dans la vallée du Mackenzie; données des relevés par listes d'espèces pour les T. N.-O. conservées par le bureau de Yellowknife du Service canadien de la faune. Les données du BBS laissent penser que, pour la plupart des espèces, les taux de détection obtenus dans les relevés par plans quadrillés en 2004 étaient typiques. Malgré des différences dans les techniques de collecte des données, qui rendent difficiles les comparaisons, les données historiques des années 1970 indiquent que la diversité d'espèces aurait été à l'époque similaire dans certains milieux, que de nouvelles espèces ont été observées en 2004 et que, toutefois, les densités globales auraient diminué. Enfin, selon les relevés par listes d'espèces, 269 espèces ont été répertoriées dans la vallée du Mackenzie, dont 75 ont été détectées dans les relevés par plans quadrillés de 2004.

On traite dans le présent document de la gestion adaptative du paysage, des stratégies de coupe avec rétention d'arbres le long du corridor pipelinier, des effets de lisière sur les oiseaux, des réponses des communautés aviennes, des indicateurs écologiques et des points à considérer quant aux aménagements futurs à l'échelle du paysage. Des recommandations touchant les études et approches futures relatives aux répercussions potentielles du gazoduc sur les écosystèmes boréaux sont présentées.

L'auteur assume seul la responsabilité des conclusions et recommandations formulées dans le présent rapport. Ces conclusions et recommandations ne sont pas nécessairement endossées ou partagées par Environnement Canada ou ses employés.

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Breeding Bird Surveys (BBS) data used in this report is thanks in part to the hundreds of skilled volunteers in Canada who have participated in the BBS throughout the years and those who have served as provincial or territorial coordinators.

John Cooper, Matt Wheatley, Paul Chytyk, Aaron Deans, Carmen Holschuh, and Suzanne Beauchesne prepared the report. All GIS analyses were conducted by Matt Wheatley.

INTRODUCTION TO THE PROJECT

The Mackenzie Valley Gas Project is the proposed development of onshore sweet natural gas fields in the Mackenzie Delta and the transporting of that gas to southern markets by pipeline along the Mackenzie River Valley. The proposed project consists of natural gas development facilities at three anchor gas fields in the Mackenzie Delta; a natural gas and natural gas liquids (NGLs) gathering system that ships natural gas and NGLs from the three fields to the Inuvik area; an NGL pipeline from Inuvik to Norman Wells; and a transmission pipeline system (Mackenzie Valley Pipeline) from Inuvik south along the Mackenzie Valley that connects to the terminus of an existing natural gas pipeline system in northwestern Alberta (Figure 1).

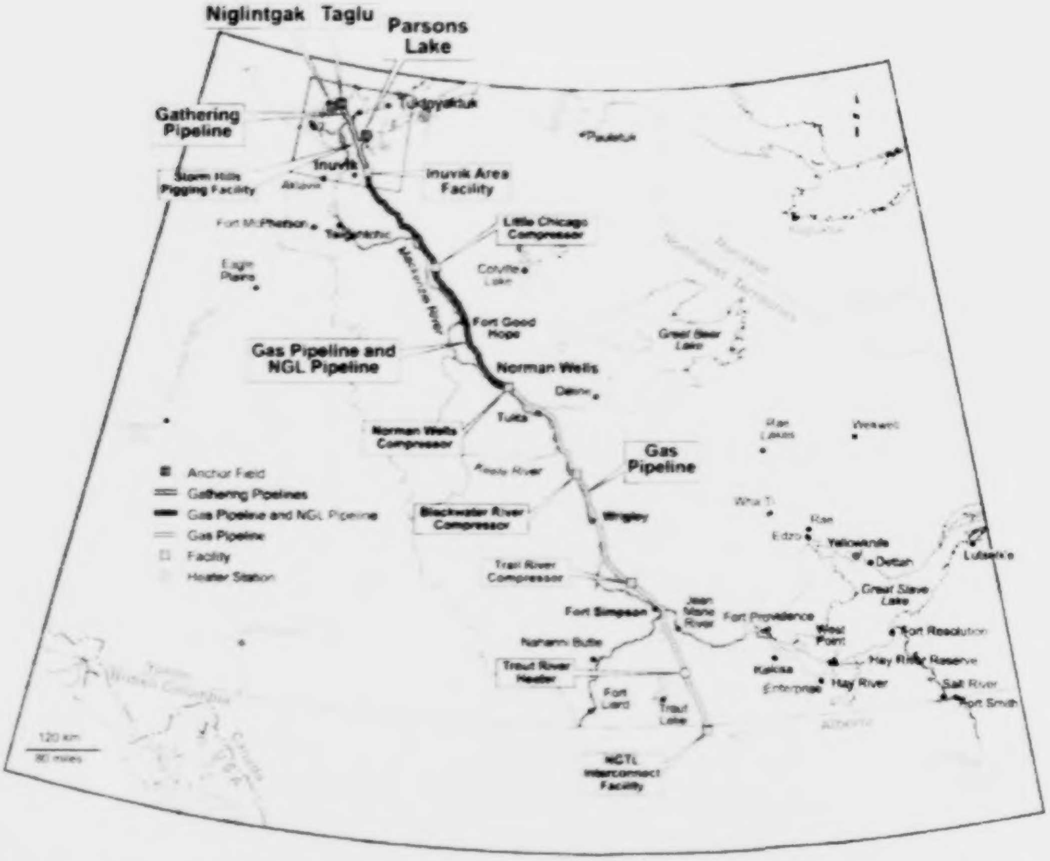

Niglintgak
Taglu
Parsons Lake
Gathering Pipeline
Tuktoyaktuk
Paulatuk
Storm Hills Pigging Facility
Aklavik
Inuvik
Inuvik Area Facility
Fort McPherson
Tsiigehtchic
Little Chicago Compressor
Mackenzie River
Colville Lake
Eagle Plains
Fort Good Hope
Great Bear Lake
Gas Pipeline and NGL Pipeline
Norman Wells
Deline
Tulita
Norman Wells Compressor
Gas Pipeline
Anchor Field
Gathering Pipelines
Gas Pipeline and NGL Pipeline
Gas Pipeline
Facility
Heater Station
Blackwater River Compressor
Wrigley
Wha Ti
Rae
Edzo
Yellowknife
Dettah
Lutselk'e
Trail River Compressor
Great Slave Lake
Fort Simpson
Jean Marie River
Fort Providence
West Point
Fort Resolution
Nahanni Butte
Hay River Reserve
Trout River Header
Kakisa
Enterprise
Hay River
Salt River
Fort Smith
Fort Liard
Trout Lake
NGTL Interconnect Facility
120 km
80 miles

Figure 1: Proposed locations of natural gas development facilities and transmission pipeline system for the Mackenzie Gas Project.

The Mackenzie Gas Project is proposed by a consortium of petroleum companies that will have co-ownership of the gathering and pipeline facilities. Ownership of the project will be proportionate to the capacity needs of each of the proponent companies. The three anchor gas fields (Niglintgak, Parsons Lake and Taglu) have estimated reserves of 164 billion m^3 (Gm^3) of sweet natural gas. The combined production rate of the three fields is expected to be 23-28 Mm^3/d of natural gas and 2,000-2,500 m^3/d of NGLs (Imperial Oil Resources Ventures Limited 2003).

Current plans for the Mackenzie Gas Project are based on a feasibility study that was completed in 2001, which assessed the regulatory approval process for project proponents. The Northern Pipeline Environmental Impact Assessment and Regulatory Chairs' Committee issued a Cooperation Plan in June 2002 that provided the framework for the regulatory approval process for the project. The location and configuration of the project facilities will be subject to further technical and commercial studies, socio-economic and environmental impact assessments (EIA), and public input.

Preliminary work for the EIA began in 2001 with the collection of baseline biophysical data and continued through 2004. In summer 2004, Environment Canada conducted songbird spot mapping surveys in the Norman Wells and Fort Simpson areas. This information was collected to provide independent information used in the environmental assessment process. This report summarizes the findings of these survey efforts, assesses information contained in other data sets, estimates losses of breeding birds and habitat from pipeline construction and discusses issues related to direct and indirect effects on birds of the pipeline.

INTRODUCTION TO THE STUDY AREA

The study area is located along the central portion of the Mackenzie River Valley along the proposed corridor for the approximate 1,300 km long transmission pipeline system. Along most of its length, the pipeline will parallel the Mackenzie River, and in some cases will cross it. The Mackenzie River is the largest north-flowing river in North America. The river is located east of the Mackenzie Mountains Range and flows along the western portion of the Northwest Territories in northern Canada. The Mackenzie River flows 4,241 km from its headwaters of Finlay River in British Columbia to its delta in the Beaufort Sea (NRC 2004). The watershed drains nearly one-fifth (1,805,200 km^2) of the landmass of Canada and is the second largest drainage basin in North America and the sixth largest in the world.

The two main tributaries of the Mackenzie River are the Liard River and Great Bear River. Rivers that flow into the Mackenzie are characterized by flow patterns dominated by snowmelt and freezing. The Mackenzie River has a mean discharge rate of 9,700 m^3/second; approximately the same as the St. Lawrence River (NRC 2004). Between May and July, river flow rate is at its maximum as melt water from snow packs flow into the basin. Flow rate decreases throughout the summer and fall and into the winter as freeze-up begins. Through January to March, base flow is at its lowest due to the subzero temperature and frozen landscape.

The proposed transmission pipeline is located in the Taiga Plains ecozone. This ecozone is approximately 80% forested and is a transitional area between tundra and northern coniferous forests (NRC 2004). Forests of this ecozone tend to have poor drainage and are dominated by open stands of black spruce (*Picea mariana*) with some tamarack (*Larix laricina*), dwarf birch (*Betula nana*) understories and Labrador tea (*Ledum glandulosum*), lichen and moss ground cover. Drier sites that are better drained are characterized by white spruce (*Picea glauca*), jack pine (*Pinus banksiana*), paper birch (*Betula papyrifera*) and trembling aspen (*Populus tremuloides*). Wetter areas are characterized by bog and fen complexes with stunted black spruce, willow and alder swales, Labrador tea and hummocky sphagnum bogs.

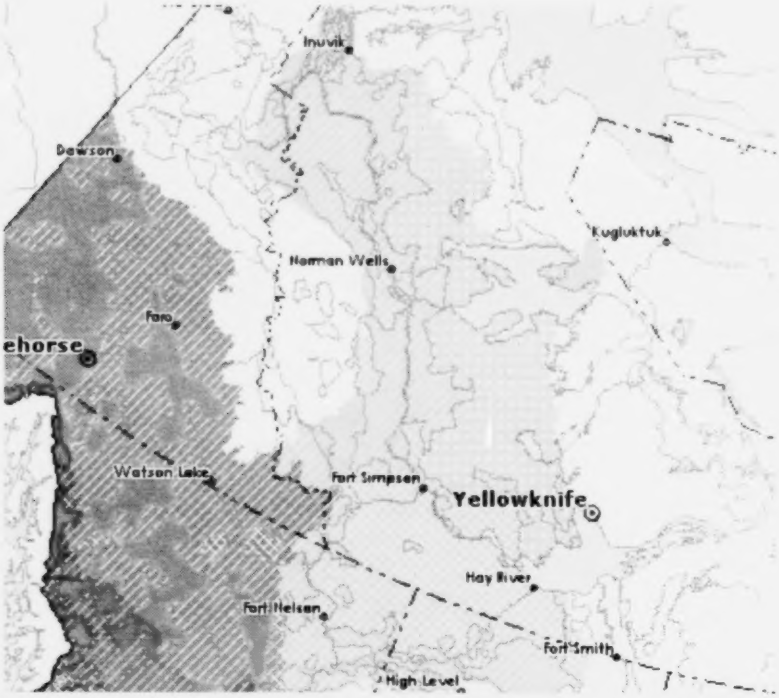


Figure 2: The Mackenzie Gas Project is located in the Taiga Plains ecozone (outlined in orange). Graphic credit: Natural Resources Canada (2004).

The proposed pipeline will cross more than 500 water bodies along its length. These water bodies vary from wetlands, ephemeral drainages to large rivers. Many of these water bodies support both anadromous and resident fish populations as well as abundant wildlife habitat and important bird breeding habitat. The Mackenzie Valley is also an important bird migration corridor that provides critical staging habitat during spring and fall for waterfowl, shorebirds and songbirds.

Introduction to Methods

Historical bird data from several sources were examined for baseline data on bird communities and species densities along the proposed pipeline corridor. Datasets were variable in scope, depending on the bird species that were surveyed, survey methodologies, and locations surveyed. Datasets that were examined included:

- Breeding Bird Survey data
- 1970s Arctic Gas Pipeline bird survey data
- NWT/NU Bird Checklist Survey data

Applicable information from each of the datasets was collated to provide baseline species densities and bird community composition data for comparison purposes.

These baseline data were then compared to data collected from 2004 songbird spot mapping plots established at two study areas near Norman Wells and Fort Simpson. The two study areas were selected as representative of habitat types in the southern portion of the Mackenzie Valley (Fort Simpson) and the northern portion of the valley (Norman Wells). Twenty spot mapping plots were established at the two study areas, 8 at Fort Simpson and 12 at Norman Wells. Vegetation data were collected at each of the spot mapping plots, which allowed for the classifying of each plot into broad habitat categories. In total, 6 habitat categories were sampled by spot mapping plots, including: black spruce-open, deciduous, fire regenerating - low shrubland, jack pine, low shrubland, and white spruce.

Songbird densities were calculated for each of the 6 habitat categories from 2004 spot mapping plots. These densities were then compared to historical bird density data for similar habitat types. Comparisons between historical data and 2004 data were also completed for bird community composition for each habitat category. These comparisons provided a preliminary overview of changes that had occurred in bird communities and species densities among different habitat types over time.

Analysis was conducted on vegetation data collected at 2004 spot mapping plots to confirm that the broad habitat categories that were assigned to each of the plots were analogous to corresponding GIS habitat polygon labels. Two GIS sampling areas were established; each sampling area consisted of a 200 km length along the 50 m wide pipeline corridor that was centred on both Norman Wells and Fort Simpson. GIS analysis determined the approximate amount of hectares for each of the 6 spot mapping habitat types that occurred in each of the two GIS pipeline sampling areas. Bird densities by habitat type calculated from the spot mapping plots were then applied to the amount of hectares for each habitat type along the two GIS pipeline sampling areas. These calculations provided estimates of potential habitat loss and bird species impacts for the two sampling areas along the proposed pipeline corridor

The results of these calculations and comparisons were then discussed within context of the proposed pipeline and the potential impacts that it would have on local bird populations. Wildlife management implications and possible mitigative measures to offset habitat and songbird loss from the proposed pipeline corridor were explored and discussed.

Objectives

The four objectives of this report are:

1. To determine bird densities for different habitat types to identify potential effects that the proposed pipeline corridor will have on local bird populations.
2. To synthesize historical knowledge and information on bird populations in areas that will be affected by pipeline development along the Mackenzie Valley.
3. To compare historical bird data to recent data collected from 2004 spot mapping plots near Norman Wells and Fort Simpson.
4. To identify possible wildlife management implications, bird habitat conservation strategies, and mitigation measures for offsetting pipeline development impacts on boreal bird populations.

CHAPTER 1 – LANDSCAPE VEGETATION AND PASSERINE HABITAT STRUCTURE OF THE MACKENZIE VALLEY GAS PIPELINE EXTENSION

INTRODUCTION

The Mackenzie Valley is the location of a proposed gas pipeline extension that will deliver sweet natural gas from production fields in the Mackenzie River delta to southern markets by the year 2008 (Imperial Oil Resources Ventures Limited 2003). The Preliminary Information Package (PIP) for the Mackenzie Gas Project was compiled by project proponents and outlines preliminary considerations for the project. The 40-50 m wide corridor of the proposed pipeline spans some 1,220 km from the Mackenzie River delta to northwest Alberta, potentially impacting some 5,400 ha of wildlife habitat along its length. The PIP provides the framework for identifying information gaps for socio-economic considerations for the project as well as a range of sustainable development concerns that should be addressed by project stakeholders and government agencies.

The Canadian Wildlife Service (CWS) of Environment Canada is federally mandated to address several regulatory process requirements and priorities for environmental impacts associated with the Mackenzie Gas Project. Included in these potential impacts are the effects that the proposed pipeline will have on avian communities along the pipeline corridor. To partially address these concerns, CWS conducted extensive songbird surveys in 2004 at two study areas along the pipeline corridor near Fort Simpson and Norman Wells. Results from these surveys were intended to allow estimates of impacts to bird populations and habitat. Field surveys in 2004 also compliment existing historical songbird data that had been collected in the early 1970s, as well as annual Breeding Bird Surveys data from the study areas and other data sets.

This report provides biological considerations for avian communities along the proposed pipeline corridor. The report attempts to synthesize historical and baseline songbird data with current information to assess bird populations that may be negatively impacted by the pipeline corridor. Songbird communities and breeding bird densities will be assessed in relation to potential habitat loss due to the proposed development. This information will provide a better understanding of the potential negative impacts that proposed pipeline may have on songbird populations and help to identify possible alternatives and solutions for mitigating these impacts.

STUDY AREA

The Mackenzie Valley

The Mackenzie Valley region is located in the Taiga Plains ecozone along the southwest portion of the Northwest Territories (Figure 2). This ecozone is predominantly a level or gently rolling plain bordered by the Cordillera Mountain Range to the west, Great Bear Lake and Great Slave Lake to the east, Mackenzie River delta to the north and the closed forests of the Boreal Plains ecozone to the south (Wilken 1986). The Taiga Plains ecozone is 575,094 ha in size, of which approximately 213,119 ha (40%) are wetlands (Wilken et al. 2003). Most of the landscape is forested or partial forested (approximately 80%) that is characterized by boreal mixed forest-tundra and open coniferous forest. Permafrost underlies much of the region and varies from the continuous permafrost zone north of Latitude 67.5° N to the discontinuous to sporadic permafrost zone south of Latitude 62.5° N (PIP 2003). Typified by generally poor drainage, the Mackenzie Valley landscape is predominantly lowland spruce bogs and wetland ecosystems.

Similar to the rest of the Canadian boreal forest, the Taiga Plains has a history of periodic large-scale disturbance from fire and insects (van Wagner 1983; Wein and Maclean 1983; McCullough et al. 1998). On average, 1% of the forests in the Northwest Territories are burned annually. The resulting forest mosaic is complex; variable forest age and structural conditions are common across the landscape (Bonan and Shugart 1989; Payette 1992). The uneven-aged structure creates diverse forest microclimates and provides habitat for diverse communities of plants and wildlife.

The forested communities of the Taiga Plains are dominated by moisture tolerant black spruce, which generally appears stunted in open, slow growing stands with areas of tamarack. In areas with better drainage, coniferous species such as white spruce and jack pine are found mixed with deciduous species such as paper birch, balsam popular (*Populus balsamifera*), and trembling aspen. Overall, due to the sub-optimal growing conditions, tree species tend to grow smaller in the Taiga Plains compared to other areas of the boreal forest. However, in areas of nutrient-enriched alluvial flats that border rivers, white spruce and balsam poplar grow to sizes comparable to conspecifics further south.

Throughout the Mackenzie Valley there are numerous areas of shrublands dominated by small trees and shrubs, including dwarf birch, willow (*Salix spp.*), alder (*Alnus spp.*), buffaloberry (*Sheperdia canadensis*), and blueberry (*Vaccinium spp.*), among others. In disturbance areas, shrubs dominate the seral landscape for decades. Lichens, herbs and mosses dominate the ground cover, often forming a thick continuous carpet. Permanent wetlands are often a mosaic of open hummocky areas mixed with sporadic patches of dense shrubbery.

Fort Simpson

Fort Simpson (elevation 170 m) is located on an island near the fork of the Mackenzie and Liard Rivers within the Great Slave Plain and the Alberta Plateau physiographic regions. Elevation ranges from 150 m near the Mackenzie River and up to 750 m to the south of Fort Simpson along the southern boundaries of the Redknife Hills. The topography is generally level with gentle undulations and a large number of wetlands are present. Landscape surface structure includes glacial till and glaciolacustrine sediments, silts and sands and organic deposits. Approximately 75% of the soils developed from

Upper Devonian fine-grained strata and Lower Cretaceous shale deposits (PIP 2003). Till and glaciolacustrine deposits are most common.

The forests surrounding Fort Simpson are predominantly coniferous and to a lesser extent, mixed-wood and deciduous stands. The forest structure is generally open and multi-layered with occasional dense mixed-coniferous or semi-closed deciduous stands. Semi-closed stands of black spruce and jack pine are predominant with understories of feather moss, bog cranberry (*Oxycoccus quadripetalus*), blueberry, Labrador tea, and lichens. Poorly drained, peat-filled depressions occur in areas and are dominated by low stands of black spruce, ericaceous shrubs and sphagnum moss (Imperial Oil Resources Ventures Limited 2003).

Norman Wells

Norman Wells is located in a lowland area between the Norman Ranges of the Franklin Mountains to the east, and the Carajou Mountains to the west. The community is situated along the north bank of the Mackenzie River, elevation 73 m. The surrounding topography is undulating with elevations up to 150 m north of Norman Wells to 300 m to the south. The surficial geology of the Mackenzie Valley around Norman Wells is complex with abundant moisture and nutrient poor soils characterized by post Lower Cretaceous lacustrine deposits of bentonitic clay shale and sandstone (Imperial Oil Resources Ventures Limited 2003). Landscape surface structure varies from peatlands and fens to glacial till and glaciolacustrine sediments.

The forest types around Norman Wells are indicative of those found predominantly in the Mackenzie Valley, which include scattered spruce-lichen stands, spruce-moss bogs and spruce-moss-lichen muskeg. Wet sites have bog-fen vegetation, such as black spruce, dwarf birch, Labrador tea, ericaceous shrub and mosses. Drier sites tend to have more white spruce, tamarack, white birch and aspen. The occurrence of fire disturbance on the Norman Wells landscape is prevalent. The forest structure is predominantly open and multiple-layered coniferous stands with areas of open mixed-wood deciduous forests.

METHODS

Study plot selection

Two study sites were selected for spot mapping bird surveys in 2004, one near Norman Wells and one near Fort Simpson. These two communities have historical Breeding Bird Survey (BBS) data for each of them as well as bird data from previous studies conducted on the proposed gas pipeline route in the 1970s. These two areas are situated approximately 475 km apart from one another and provide a representative assortment of the habitat types that are encountered along much of the proposed pipeline corridor. The study areas were located adjacent to paved roads near the two communities, providing easy access and logistics for surveys.

Twenty spot mapping plots were established and surveyed. Each plot was approximately 12 ha in size. Plots were distributed in 6 different habitat types that are prevalent along the proposed pipeline route near Fort Simpson and Norman Wells. Habitat types were not sampled equally on purpose. Effort was allocated based on an *a priori* analysis of the approximate frequency distribution of habitats along the proposed pipeline in each study area. (Table 1).

Table 1: Number of spot mapping plots sampled by habitat type near Norman Wells and Fort Simpson, NT.

Habitat Type	**Number of Plots Sampled**		
Sampled	**Norman Wells**	**Fort Simpson**	**Total**
Black Spruce-Open	3	4	7
Deciduous	1	1	2
Fire Regenerating-Low Shrubland	5	0	5
Jack Pine	0	1	1
Low Shrubland	0	1	1
White Spruce	3	1	4
Total	**12**	**8**	**20**

GIS data calculations

Main Coverages -- Digital habitat coverages were acquired for the Fort Simpson and Norman Wells areas from NWT government sources. We acquired coverage for in excess of 100 km north and south of both Fort Simpson and Norman Wells. These were LandSat grid images with a 30-m pixel grain. Images were imported into ArcView (v.3.3) and linked to a main vegetation spreadsheet providing a level 4 habitat classification for each grid cell (based on the NWT Landcover Classification). Conversion to shapefile format resulted in over 3 million features, so study areas were clipped from the grid themes using grid-tool clip extensions in ArcView. All coverages were reprojected as required.

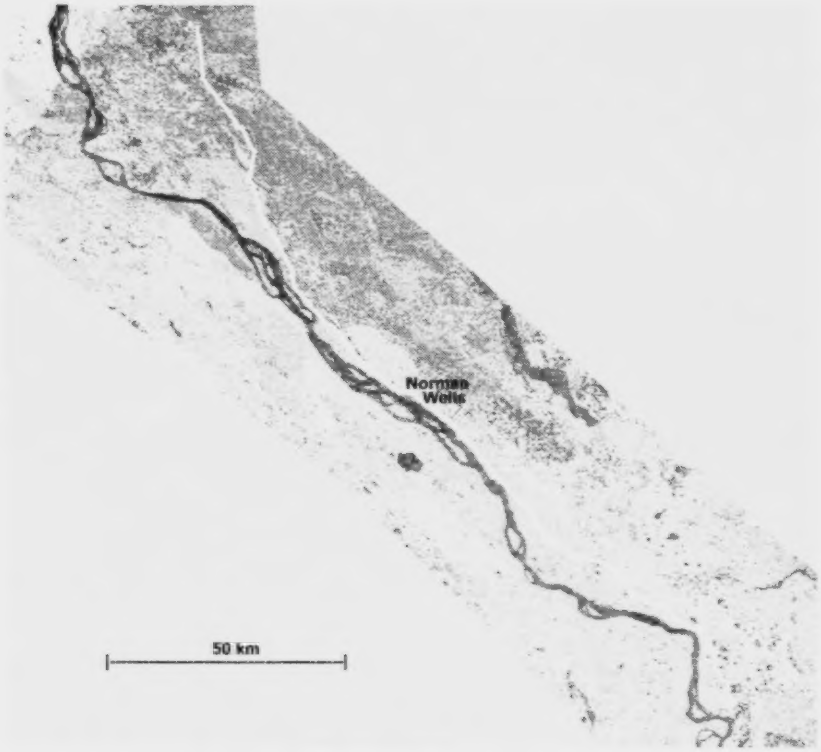


Figure 3: Satellite imagery of the proposed pipeline corridor (in yellow) 100 km north and south of Norman Wells, NT used for habitat analysis for this study.

Polygon Classifications – Grid cells were classified based on spectral signatures via satellite and categorized based on the NWT Landcover Classification System. Ground truthing was completed in some areas, and in the LandSat version we used (October 2004) the following precautions came with the data:

1. Herbaceous and wetland categories (in the non-forested level 2) are relatively less-reliable in this version of the NWT Land Cover Classification. Spectral signatures of these 2 classes were influenced significantly by fluctuation in surface moisture levels during data acquisition by the satellite.

2. Overlaps in the classification of "well-drained" and "productive" sites of closed canopy of conifer is common.

3. "Jackpine" may sometimes overlap with the "spruce-lichen boreal forest" category, but a frequency of occurrence estimation has not been calculated.

Thirteen habitat types were contained in the LandSat database (Table 2).

Table 2: Habitat types in the Landsat database.

black spruce closed	mixed forest
black spruce open	sphagnum moss
deciduous	spruce-lichen boreal forest
fire regen/low shrubland open	tall shrubland - immature decid
herbaceous	wetlands
lichen dominant	white spruce
low shrubland	

Black spruce is the most dominant habitat by area and was mostly categorized within "spruce-lichen boreal forest". Because many of the bird sampling grids were located within black spruce habitat we separated "spruce lichen boreal forest" into "open black spruce" and "closed black spruce" based on the habitat classification information provided as meta-data to the Landsat coverages, and by referring to levels 1 through 3 of the NWT Landcover Classification for each grid cell. No other classification manipulations were done to the Landsat data.

Pipeline Digitizing – For 100km north and 100km south of both Fort Simpson and Normal Wells, we digitized the proposed Mackenzie Gas Pipeline Route into GIS. This was digitized using 1:250,000 Mackenzie Gas Project Camsell Bend PIP Pipeline Routing Maps of the April 2003 proposed pipeline route and plotted onto geo-referenced digital satellite imagery. Pipeline width was set at 50m. Given the relatively large-scale routing maps used for this project, we approximate a spatial error for the digitized pipeline route of within 3.5 grid cells (roughly 90m), especially considering the formal environmental assessment is being done on an area surrounding the proposed route.

Sampling Grid Data

Sixteen vegetation plots with radii of 11.3 m each were completed for each spot mapping plot. Habitats in each plot were described by using detailed vegetation measurements with methodology established by the Canadian Wildlife Service. Seven vegetation variables were collected from each plot.

Grid-level Vegetation – Vegetation was sampled and mapped for each spot mapping grid. Sixteen vegetation plots were completed for each grid with the centre of the 11.3m radius plot at: Lines B, D, F; Stations 50, 150, 250, 325; Line H: the centre of the plot was placed 11.3m west of 50, 150, 250, 325 if the letter lines (A, B, C etc.) on the grid are running north/south. Within each plot the following were recorded:

1. Number of trees -- Trees were classified as any tree species >2m tall and >8cm DBH. Alder and willow were excluded. All trees were counted within the full veg plot.
2. Saplings and Poles -- Saplings were classified as any TREE species 0-2cm in dbh, but >2m tall. Poles were tree species 3-7 cm in dbh, but >2m tall. All saplings and poles were counted within the full veg plot.
3. Overall community composition -- Recorded in context of dominant species by strata. A typical example would be Aspen-White Spruce/Green Alder/low-bush cranberry/Bunchberry. Strata were: Canopy/Subcanopy/Tall shrub layer/shrub layer/forb layer.
4. Tall Shrubs -- Number of stems of tall shrubs by species (almost exclusively Alnus spp. or Salix spp.) within the NE and SW quarters of the 11.3m radius.
5. Average Canopy Height – Recorded from canopy trees within each veg plot (using clinometer).
6. Canopy cover - Using an occular tube looking straight up at the canopy, at every third step along the 70 m tape line that leads to the outer plots (plots #2-4) the number of hits AND misses (presence or absence of canopy within the ocular tube) were recorded. Canopy cover was calculated as a percentage of hits.

Sampling grids were categorized into habitat types based on their vegetation characteristics to correspond to NWT Landcover Classification categories as described for the Landsat coverages.

Multivariate ordinations were done to examine how each grid's vegetation community corresponded to these categories.

Correspondence Analyses -- General

Most of the spot map grids were located in relatively homogenous habitat, but some contained patches of different habitat types within the grid, possibly creating new habitat categories and affecting the bird community structure therein. Thus, we needed to decide whether the grids containing other habitat patches were different enough to either create a new habitat category, or subsample the bird community from the patches within each grid. Additionally, we needed to examine whether habitat categories assigned to NWT LandSat grid cells could be assigned appropriately to spot mapping grids based on vegetation sampling done at each grid in 2004. This required simultaneous consideration of all vegetation variables, so we employed multivariate ordination, specifically Detrended Correspondence Analysis (DCA).

DCA uses hierarchical agglomerative clustering to define sample plots based on their ecological similarity/dissimilarity in multidimensional ordination space from a complex set of environmental variables. Variables used here were the vegetation and bird communities. This method "de-trends" the data by segmenting both ordination axes and centering them on zero to remove the "arch effect" common to Principle Components Analysis. Consequently, eigen values are not used to suggest percent variability explained. Rather, the interpretation is graphical; spot mapping plots with similar vegetation community types cluster closer together in ordination space. DCA was used to examine whether there was correlation between habitat categories assigned to 2004 spot mapping grids and broad habitat classifications used for NWT Landsat polygons. We also used this technique to explore bird community composition relative to assigned habitat categories for each study area.

This analysis results in a graph that shows "similarity clustering" among grids based on the community structure of either vegetation or songbirds. Grids that are similar in community structure appear closer together on the graph. Components of the community structure that are driving either clustering or separation of grids are also plotted (in red). Structural components furthest from the graph's origin have the strongest effect in pulling grids in their direction. Likewise, components in the complete opposite direction from the origin are also important as they denote elements completely missing from certain grids, or elements of dissimilarity.

Ultimately one can explore whether: (a) grids assigned to similar habitat categories are similar in vegetation structure; (b) assigned habitat categories reflect real environmental gradients based on sampled vegetation (a corollary of (a)); and (c) bird communities are structuring based on habitat categories. For all of these, DCA also allows one to determine what component(s) of the community cause similarity or dissimilarity among grids.

RESULTS

Structural characteristics in Mackenzie Valley forests

Data on the forest characteristics of twenty spot mapping plots near Norman Wells and Fort Simpson revealed a high level of structural complexity in Mackenzie Valley forests. The forested landscape varied from open lowland coniferous bogs to semi-closed mixed deciduous stands to post-fire regenerating shrublands. In all, six different habitat classifications were sampled that included seven tree species and three predominant shrub species. Overall, the study areas were characterized by a range of different tree species, variable canopy cover, and a variety in the amount of advanced regeneration and shrub cover in the understory.

Fort Simpson

Eight study sites were sampled in the Fort Simpson area for vegetative characteristics. These study sites represented five different habitat types: black spruce-open, white spruce, jack pine, low shrubland, and deciduous. Overall, stands associated with the Fort Simpson area were typically semi-closed to open with a diverse variety of tree and understory species.

Black spruce-open habitats represented four of the eight study plots within the Fort Simpson area. These stands were predominantly black spruce (typically >70% of the canopy species), but also included variable amounts of white spruce, tamarack, jack pine, and balsam poplar (Table 3). Occasional trembling aspen and paper birch were also found in these habitats. Canopy closure was variable among plots. One black spruce-open plot (West Nile) had only 11% canopy cover consisting entirely of black spruce and tamarack. This plot also had the lowest shrub densities (331 stems/ha) of any of the sites (Table 5). Among the other 3 black spruce-open plots, understories were diverse, with most saplings equally black spruce and tamarack, and variable amounts of balsam poplar, white spruce, trembling aspen and paper birch. Although present in the canopy, jack pine saplings were almost absent in the understory of black spruce-open stands. Green alder was present in the shrub layer in varying amounts with willow recorded less frequently (Table 6).

One white spruce habitat plot was sampled at Fort Simpson. The canopy was semi-closed (60.7% canopy cover) and was predominantly white spruce, with equal amounts of jack pine and trembling aspen, with some paper birch and the occasional balsam poplar (Table 3). The understory contained moderate amounts of advanced growth (37 stems/ha) and diverse saplings species including white spruce, paper birch, trembling aspen, balsam poplar and jack pine were recorded (Table 5). The shrub layer contained dense thickets of green alder (3554 stems/ha) and occasional willow (Table 6).

One jack pine habitat plot was sampled at Fort Simpson. Canopy cover was predominantly jack pine (72.8%) with some trembling aspen (24.7%), and occasional white spruce and paper birch (Table 3). The understory was predominantly trembling aspen and jack pine saplings, with some paper birch and white spruce (Table 5). The shrub layer had the highest densities of green alder (7394 stems/ha) among all habitat plots in the Fort Simpson area (Table 6).

The one sample plot of low shrubland habitat at Fort Simpson contained several tree species despite its open shrubland characteristics. Trembling aspen, jack pine and white spruce were present in the mostly open canopy (10% canopy cover) (Table 3). These species were also present in the sapling understory layer, as well as paper birch and black spruce (Table 5). The shrub layer was dense (10,391 stems/ha) and contained all three of the most common shrub species (green alder, dwarf birch and willow) in high numbers (Table 6).

The one deciduous habitat plot in the Fort Simpson area was characterized by the highest canopy closure (86.5%) sampled in all the plots (Table 3). Canopy cover was predominantly trembling aspen (71%) and paper birch (25.4%), with minor amounts of white spruce and jack pine. Understory saplings were mostly paper birch and trembling aspen saplings with some white spruce and balsam poplar (Table 5). The shrub layer was relatively dense with green alder most prevalent (4463 stems/ha) with some willow species (314 stems/ha) (Table 6).

Table 3. Tree species composition and percent cover for 2004 bird spot mapping plots near Fort Simpson, NT, as derived from site-specific data collected at each plot.

Spot Mapping	LandSat Habitat	Tree Species Percent Canopy Cover								Canopy
Plot Name	Classification	BEPA	LALA	PIBA	PIGL	PIMA	POBA	POTR	None	Cover
Anthrax	white spruce	6.9		17.6	58.2		0.4	16.9		60.75
Bird Flu	black spruce-open	0.3	4.6	2.8	17.1	74.2	0.1	0.9		26.13
Botulism	black spruce-open	0.2	5.1	0.7	17.4	68.8	0.8	6.6	0.5	18.97
Cholera	black spruce-open		5.9	3.7	7.7	80.8	1.2	0.8		34.49
West Nile	black spruce-open		24.7			75.3				11.31
Ebola	jack pine	0.3		72.8	2.2			24.7		52.00
Malaria	low shrubland			25.5	21.8	3.6		33.9	15.2	10.00
Rabid	deciduous	25.4		0.2	3.2			71.2		86.54

* See Appendix 3 for a list of tree species names and codes.

Table 4. Tree species composition and percent cover for 2004 bird spot mapping plots near Norman Wells, NT, as derived from site-specific data collected at each plot.

Spot Mapping	LandSat Habitat	Tree Species Percent Canopy Cover							Canopy
Plot Name	Classification	BEPA	LALA	PIGL	PIMA	POBA	POTR	None	Cover
Burn1	fire regen - low shrub			6.2	6.2			87.6	-
Burn2	fire regen - low shrub							100.0	-
Burn3	fire regen - low shrub							100.0	-
Burn4	fire regen - low shrub							100.0	-
Snipe	fire regen - low shrub			6.4	61.2			32.4	-
Deciduous	deciduous	3.1		4.7	0.1	13.2	78.9		54.54
Meteo1	black spruce-open		2.7	7.8	89.2			0.2	10.82
Meteo2	black spruce-open			15.9	84.1				3.29
Vermillion	black spruce-open	2.0	8.2	1.7	88.2				2.36
Mixed	white spruce	15.8		65.1		10.8	8.2		48.05
Spruce1	white spruce		4.2	82.1	13.3			0.4	5.66
White Spruce	white spruce	1.1	0.7	86.1	12.1				14.79

* See Appendix 3 for a list of tree species names and codes.

Table 5. Number of saplings (>2 m height) per ha for 2004 bird spot mapping plots near Fort Simpson, NT.

Spot Mapping Plot Name	LandSat Habitat Classification	Number of Saplings (>2 m height) per ha							
		BEPA	LALA	PIBA	PIGL	PIMA	POBA	POTR	None
Anthrax	white spruce	11		1	15		2	7	
Bird Flu	black spruce-open	2	13		1	15	1	3	
Botulism	black spruce-open	1	12		2	16	5	3	
Cholera	black spruce-open	2	5	1	4	16	5		
West Nile	black spruce-open		14			15			
Ebola	jack pine	2		13	1			16	
Malaria	low shrubland	1		1	1	2		1	2
Rabid	deciduous	16			2		2	13	

* See Appendix 3 for a list of tree sapling species names and codes.

Table 6. Number of shrubs (<2 m height) per ha for 2004 bird spot mapping plots near Fort Simpson, NT.

Spot Mapping Plot Name	LandSat Habitat Classification	Number of Shrubs (<2 m height) per ha		
		ALCR	BEGL	SALI
Anthrax	white spruce	3554		34
Bird Flu	black spruce-open	1839		545
Botulism	black spruce-open	696		105
Cholera	black spruce-open	2289		199
West Nile	black spruce-open			331
Ebola	jack pine	7394		52
Malaria	low shrubland	2169	4448	3774
Rabid	deciduous	4463		314

* See Appendix 3 for a list of shrub species names and codes.

Norman Wells

Twelve study sites were sampled in the Norman Wells area for vegetative characteristics. These study sites represented four different habitat types: fire regenerating-low shrubland, black spruce-open, white spruce, and deciduous (Table 4).

The most common habitat type sampled at Norman Wells was post-fire regenerating shrublands. Five study plots of this habitat type were sampled, four of which (plots Burn1-4) were recent burns with no trees larger than 2 cm dbh. The fifth post-fire plot (Snipe) contained trees greater than 8 cm dbh. The advanced post-fire regenerating trees recorded in plot "Snipe" were mainly black spruce and to a lesser extent white spruce. Advanced regeneration of black spruce, tamarack, paper birch and trembling aspen saplings were recorded in all five plots; plot "Snipe" also contained some white spruce saplings (Table 7). The shrub-layer of these post-fire plots was predominantly willow and to a lesser degree dwarf birch (Table 8). In the understory of the more advanced post-fire plot "Snipe", green alder (*Alnus crispa*) was more abundant than dwarf birch.

Table 7. Number of saplings (>2 m height) per ha for 2004 bird spot mapping plots near Norman Wells, NT.

Spot Mapping Plot Name	**LandSat Habitat Classification**	**Number of Saplings (>2 m height) per ha**							
		BEPA	**LALA**	**PIGL**	**PIMA**	**POBA**	**POTR**	**SALI**	**None**
Burn1	fire regen-low shrub	1	4		2		1		11
Burn2	fire regen-low shrub	2	5		3		2		12
Burn3	fire regen-low shrub	3	6		4		3		13
Burn4	fire regen-low shrub	4	7		5		4		14
Snipe	fire regen-low shrub	2	6	2	9		1		4
Deciduous	deciduous	9		6		17	16	3	
Meteo1	black spruce-open	1	10	1	16				
Meteo2	black spruce-open		10	5	11				
Vermillion	black spruce-open	2	11		16				
Mixed	white spruce	16		16		5	12		
Spruce1	white spruce		11	11	5				
White Spruce	white spruce	2	4	14	3	1			

* See Appendix 3 for a list of tree sapling species names and codes.

Table 8. Number of shrubs (<2 m height) per ha for 2004 bird spot mapping plots near Norman Wells, NT.

Spot Mapping Plot Name	**LandSat Habitat Classification**	**Number of Shrubs (<2 m height) per ha**		
		ALCR	**BEGL**	**SALI**
Burn1	fire regen-low shrub		1048	2913
Burn2	fire regen-low shrub		1049	2914
Burn3	fire regen-low shrub		1050	2915
Burn4	fire regen-low shrub		1051	2916
Snipe	fire regen-low shrub	1241	140	3831
Deciduous	deciduous	5196		109
Meteo1	black spruce-open	2743	1179	895
Meteo2	black spruce-open	1055	962	402
Vermillion	black spruce-open	909		799
Mixed	white spruce	1659		449
Spruce1	white spruce	2640	297	1053
White Spruce	white spruce	3959	11	421

* See Appendix 3 for a list of shrub species names and codes.

Three sample plots were established for both black spruce-open and white spruce habitats at Norman Wells. Both of these habitat classifications had black and white spruce present to varying degrees and canopy closures. Those stands classified as black spruce-open tended to have >80% of black spruce canopy trees, while those designated white spruce had canopies comprised of at least 65% white spruce (Table 4). All black spruce-open habitats sampled also contained tamarack and occasionally paper birch. Understories were predominantly black spruce and tamarack and to a lesser extent white spruce and paper birch (Table 7). Shrub layers were relatively dense; green alder, dwarf birch and willow were most predominant (Table 8).

White spruce represented up to 86% of the canopy layer in white spruce habitats sampled (Table 4). Two of the three white spruce stands sampled each contained 13% black spruce and some tamarack in the canopy, while the third "Mixed", contained no black spruce in the canopy. The "Mixed" white spruce plot contained a greater proportion of deciduous tree species (34.8%) than the other white spruce plots. Advanced growth in the understory of the "Mixed" white spruce plot had white spruce and paper birch saplings in about equal portions followed by trembling aspen and balsam poplar saplings (Table 7). Sapling understories of the white spruce habitats consisted of white spruce, tamarack and black spruce and occasional paper birch and balsam poplar. The shrub layer was predominantly green alder in each of the white spruce stands (up to 3959 stems/ha) (Table 8). Willow (up to 1053 stems/ha) and dwarf birch (up to 297 stems/ha) were also present in the shrub layer.

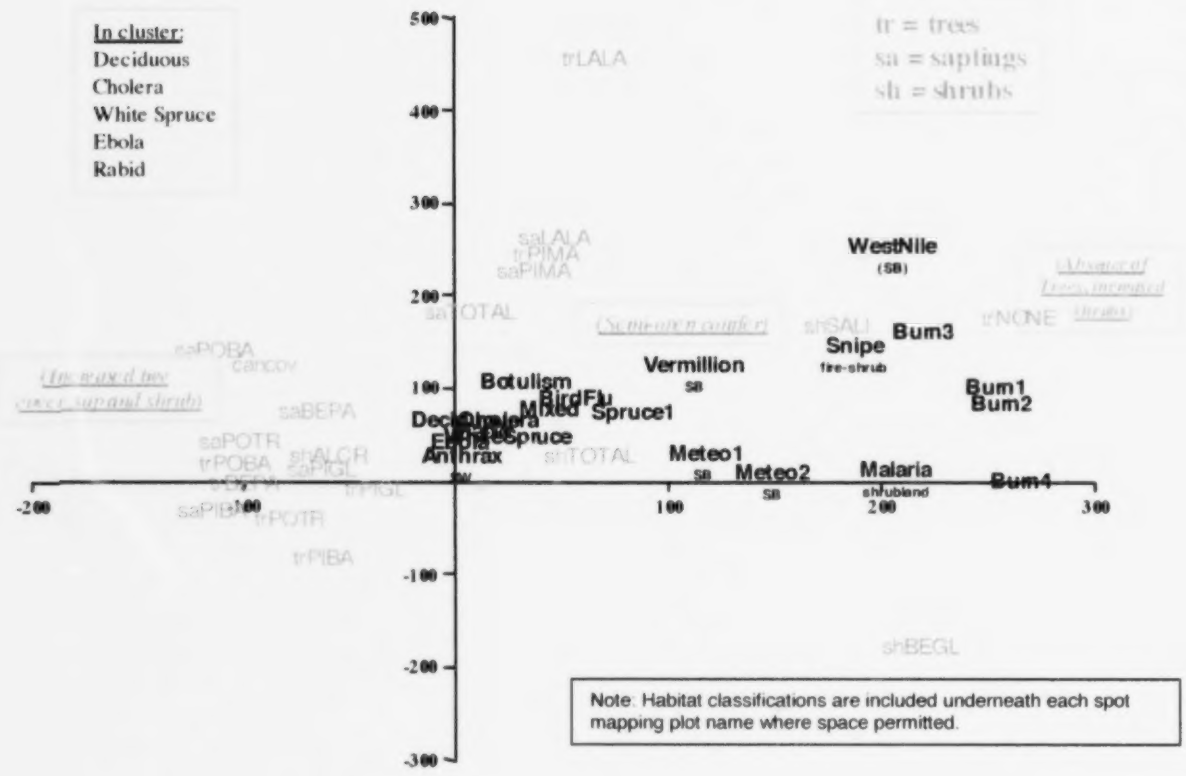
Only one deciduous habitat plot was sampled at Norman Wells. The canopy consisted mostly of trembling aspen (79%) and balsam poplar (13%) with occasional white spruce and paper birch (Table 4). Sapling understories were mostly balsam poplar and trembling aspen in nearly equal numbers, with some paper birch and occasional white spruce (Table 7). The shrub layer in the deciduous habitat plots had the greatest stems per hectare densities (5305 stems/ha) compared to the other habitat types sampled at Norman Wells (Table 8). Green alder was the predominant shrub species (5196 stems/ha) with small amounts of willow (109 stems/ha).

Habitat types by landscape area

Detrended Correspondence Analysis for vegetation communities in the 2004 spot mapping plots suggests that broad category types assigned to each of the grids are indicative of the actual vegetation communities field sampled in 2004 (Figure 4).

From right to left on the horizontal axis the DCA graph shows a vegetation gradient from open treeless areas, through semi-open conifer areas, to more closed-canopy deciduous areas, and these correspond to assigned habitat categories from open burned grids to closed forested grids. The absence of trees (trNONE) and the presence of Salix shrubs (shSALI) are strongly associated with burn grids (Burn 1-4), and with open, shrub-dominated grids (Snipe, Westnile). In comparison, plots in the middle of the graph are open forested areas such as black spruce bog forests, and are associated with conifer species (trPIMA, saLALA) and increased understory shrub cover (shTOTAL), whereas plots to the left along the vertical axis are forested areas with a relatively high mature tree component (trPIGL, trPOTR), closed canopies (cancov) and high deciduous sapling density.

This analysis lends support to the assumption Landsat habitat classifications used for GIS analyses are similar to assigned habitat categories of the spot mapping plots based on 2004 sampled vegetation.



* See Appendix 3 for a list of plant species names and codes.

Figure 4: Detrended Correspondence Analysis graph for vegetation communities by 2004 spot mapping plots near Fort Simpson and Norman Wells, NT. Axis 1 is a gradient from (left to right) treed plots to non-treed plots. Axis 2 is a weaker, less important gradient with much less plot separation from (top to bottom) larch and white spruce areas to pine and deciduous areas.

DISCUSSION

The most prevalent forest type found in northern Mackenzie Valley, represented by the Norman Wells study area, was black spruce-open forest, characterized by scattered spruce-lichen muskeg, spruce-moss muskeg and spruce-moss-lichen muskeg. The tree layer of these habitats was dominated by black spruce (5-10 m high), with typically some tamarack and paper birch. The shrub layer (which was absent, scattered, or open) of black spruce-open stands consisted of young black spruce, willow, and alder. The dwarf shrub layer was composed mainly of dwarf birch, Labrador tea, bog cranberry, and other *Vaccinium* species.

Black spruce bog habitats characterized wet lowland areas. In these habitats, black spruce was typically interspersed with tamarack with canopy heights generally <13 m. The shrub layer was variable and consisted of willow, alder, dwarf birch, spruce and tamarack (1-3 m high). Ground cover varied between sphagnum moss and sedge in wet areas to lichen, feather moss, and *Vaccinium* spp. in drier terrain.

Open and semi-closed coniferous forest varied in structure and composition as the moisture gradient changed across the landscape. Typically semi-closed forests consisted of white spruce (10-23 m high), black spruce (5-17 m in high), or a combination of the two with scattered tamarack and paper birch.

At southern Mackenzie Valley sites near the Fort Simpson study area, there were stands of jack pine (10-20 m high) mixed with trembling aspen and occasional white spruce and paper birch. The shrub layer, which was often dense in open and stunted forests, ranged in density from scattered to contiguous cover and usually consisted of alder, willow, and less frequently dwarf birch.

Deciduous forests consisted of trembling aspen, paper birch, balsam poplar, alder, and willow. Occasionally scattered jack pine, black and white spruce were also present. Tree height usually ranged from 8-20 m with alder and willow components that rarely exceeded 7 m in height. The shrub layer, when present, was scattered or closed (depending on the height and density of the tree layer) and consisted primarily of alder and willow and occasionally buffaloberry. Ground cover most frequently consisted of leaf litter, feather moss, and *Vaccinium* spp.

In open and semi-closed mixed forests, the canopy layer consisted of both coniferous black spruce and/or white spruce with varying amounts of trembling aspen, balsam popular, paper birch, and tamarack. Canopy height averaged 8-11 m, with trembling aspen, balsam poplar, and black spruce occasionally reaching up to 17 m and white spruce up to 27 m. Shrub cover varied between closed to semi-closed; this layer consisted of alder and willow with occasional dwarf birch and spruce saplings. Ground cover consisted of feather moss and *Vaccinium* species.

Shrubland habitat types generally occur on moist to wet post-fire sites. Regenerating trees in the understory were at variable stages of development and were interspersed among alder, willow and dwarf birch. Advanced sapling regeneration in post-fire shrubland eventually outgrew the shrub layer and trees over 2 m in height were common. Shrubland habitats had generally dense shrub layers and thick vegetation. The ground cover was often contiguous peat moss over 1 m thick and contained *Vaccinium spp.*, among others herbaceous plants.

CONCLUSIONS

Six different LandSat habitat classification types were sampled in the Mackenzie Valley for this study including, black spruce-open, fire regenerating - low shrubland, white spruce, deciduous, jack pine and low shrubland. Defined by their predominant canopy cover, these distinct landscape classifications represent different forest ecosystems that are representative of the dominant habitat types across the Mackenzie Valley landscape. Although finer-scale categorization of the Mackenzie Valley forest structure may define forest complexity more thoroughly, that degree of precision was not warranted for this study. Detrended Correspondence Analysis for vegetation communities sampled at the 2004 spot mapping plots suggested that the broad category types assigned to each of the spot mapping plots were accurate descriptors of the actual vegetation communities that were observed in the field. The six habitat types that were sampled for the study were selected as representative habitats as they relate to dominant bird communities found in the Mackenzie Valley. These broad habitat categories, and the quantification of their associated bird communities and species densities, will help to identify and evaluate the potential effects the proposed pipeline corridor will have on local bird populations.

CHAPTER 2 – THE AVIAN COMMUNITIES OF THE MACKENZIE VALLEY

INTRODUCTION

Bird communities that may be impacted by the Mackenzie Valley gas pipeline were determined from various methods. Spot map surveys were conducted in 2004 near Norman wells and Fort Simpson to determine densities of breeding birds. These data were used in combination with previously described data on vegetation to estimate losses of birds due to pipeline construction. Breeding bird surveys from three locations (Norman Wells, Fort Simpson, Fort Liard) were analyzed and used to determine how well the spot mapping surveys captured the breeding bird community present in parts of the Mackenzie Valley. Data and reports from the 1970s Arctic gasline environmental assessment were analyzed to also assist with determining if data from 2004 spot map plots represented "normal" bird diversity and densities. Bird/habitat correlations were conducted to help describe bird communities present in each habitat type analyzed. Finally, general data on bird occurrences in the Mackenzie Valley were reviewed to provide an over all picture of bird presence in the valley.

The overall purpose of these analyses and reviews is to provide data and satisfactory levels of confidence for calculations of estimated habitat and breeding bird losses due to construction of the Mackenzie Valley gas pipeline.

METHODS

Spot mapping (2004)

Spot mapping bird surveys were conducted in accordance to standard survey protocol as outlined in Bibby et al. (2000) and are summarized below. Spot map grids were establish in habitat areas prior to surveys; 12 grids of 4 habitat types near Norman Wells and 8 grids of 5 habitat types near Fort Simpson were surveyed (Figure 5). Each grid was 12.25 ha. Surveys were not conducted during periods of rain or moderately high winds that reduced songbird activity or the ability of observers to detect birds. Each grid was surveyed 10 times during 5-30 June 2004. Surveys were conducted from sunrise until 6.0 hours after sunrise. Starting and ending points for each of the spot maps were alternated for each successive visit.

For each survey, an observer walked parallel grid lines and recorded all birds that were detected within 30 m. These observations were recorded with a solid lined circle around the 4-letter species code; a dot indicated the exact location of the singing or calling bird. Detections that occurred >30 m away were indicated with a dashed circle, indicating an approximate location of the bird. If these birds were subsequently encountered within 30 m on an adjacent grid line, the observer would remark the observation with a solid line circle at the new exact location. Simultaneously singing males, on adjacent territories, were indicated by a dashed line drawn between the 2 bird detection points.

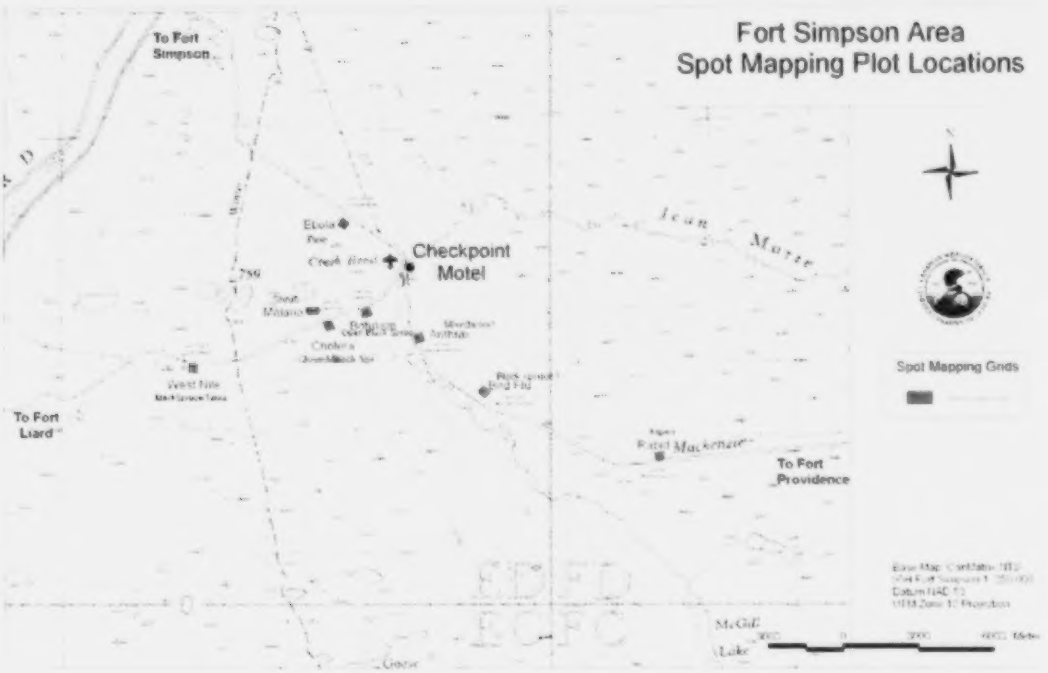

Fort Simpson Area
Spot Mapping Plot Locations
To Fort Simpson
Ebola
Checkpoint Motel
759
Cholera
West Nile
To Fort Liard
Jean Marie
To Fort Providence
Spot Mapping Grids
McGill Lake
Goose

Figure 5: Locations of 8 spot mapping plots and their associated habitat types near Fort Simpson, NT.

All birds detected visually were indicated by a dot next to the 4-letter species code. All nests were recorded and were subsequently revisited to determine nesting chronology. Birds that flew over the plot, but were not necessarily on territory, were also recorded. All birds that were detected outside of the plot, and within 50 m of the spot map boundary, were recorded.

GIS Spot Mapping Data Analysis

After 10 visits, breeding bird territories were delineated by circling clusters of same-species observations and forming approximate (hand drawn) minimum convex polygons representing individual bird territories. Exceptions and nuances were followed as per the discussion on pages 51-59 of Bibby (2000). These were scanned and geo-referenced into the GIS, and territory polygons were digitized for each songbird species on each grid. The territory centroid was used to determine whether each individual territory was counted as on or off the grid; centroids that fell on the grid were included in density estimates; centroids that fell off the grid were counted only as present but were not used in density estimates. Transient species and birds observed flying over (but not singing) also were recorded.

GIS Data Integration

Habitat loss Pipeline – Using the proposed, digitized pipeline route, we selected for all polygon features that fell within this 50m corridor for 100km north and south of both Fort Simpson and Norman Wells. These features were clipped out and area calculations were done for each polygon, and then summarized by area based on habitat category. This resulted in the total amount of habitat removed by area for each habitat category.

Habitat Loss and Songbirds – Spot mapping grids were fixed in area (12.25 ha each). We calculated density estimates by species for all grids within both Norman Wells and Fort Simpson. This was done by calculating a habitat-specific single-grid density for each songbird species that was counted on-grid on *at least* one grid. We then calculated the average density by species within each habitat category by averaging habitat-specific single grid densities. This resulted in an average density by habitat for each species. Total songbird loss by habitat was calculated by multiplying the total area of habitat loss from the proposed pipeline route by the habitat-specific density for each songbird species.

It is acknowledged that the number of sample plots, from only two areas of the Mackenzie Valley only allows for limited extrapolation, covering a limited number of species.

NWT Bird Checklist data

The NWT/Nunavut Bird Checklist data is a database containing bird observations from northern Canada, including numerous records from the Mackenzie Valley. The database is compiled by the Canadian Wildlife Service in Yellowknife, NT. The database contains approximately 39,000 bird records from 1972-2004 (for NWT only). Data is not collected systematically, but includes records from several government surveys conducted in the 1970s, various other historical records and recent (1995 onwards) observations by biologists and naturalists. Each bird record includes a description of the location of the observation, the latitude and longitude coordinates of the observation, the date and duration of the observation, and a general comment on the presumed breeding status of the bird at the time of the observation.

Two hundred seven bird species have been recorded in this database: 165 species at Norman Wells and 195 species at Fort Simpson (Table 9). A review of Table 9 reveals considerable differences in indexes of species occurrence and frequency of occurrence at the two locations.

Table 9. Bird Species observed 100 km north and south of Norman Wells and Fort Simpson, NWT, 1972-2004. Total count for each area represents the number of times each occurs in the checklist database.

Species	Norman Wells	Fort Simpson
Red-throated Loon	1	5
Pacific Loon	24	
Common Loon	4	8
Yellow-billed Loon	1	
Pied-billed Grebe		4
Horned Grebe	20	15
Red-necked Grebe	7	10
Great Blue Heron		3
Greater White-fronted Goose	2	16
Snow Goose	6	5
Canada Goose	26	46
Trumpeter Swan	1	1
Tundra Swan	7	3
Gadwall	5	4
American Wigeon	37	46
Mallard	48	56
Blue-winged Teal	18	21
Northern Shoveler	39	18
Northern Pintail	30	18
Green-winged Teal	32	20
Canvasback	6	5
Redhead	3	1
Ring-necked Duck	13	13
Greater Scaup	20	6
Lesser Scaup	32	15
Surf Scoter	20	4
White-winged Scoter	10	7
Long-tailed Duck	14	6
Bufflehead	19	39
Common Goldeneye	16	32
Barrow's Goldeneye	12	1
Red-breasted Merganser	2	1
Common Merganser	1	3
Ruddy Duck	3	
Osprey		2
Bald Eagle	7	16
Northern Harrier	20	16
Sharp-shinned Hawk	6	6
Northern Goshawk	7	3
Broad-winged Hawk		1
Red-tailed Hawk	4	11
Rough-legged Hawk		7
Golden Eagle	4	1
American Kestrel	30	33
Merlin	5	11
Peregrine Falcon	5	5
Gyrfalcon	1	5
Ruffed Grouse	5	22
Spruce Grouse	1	8
Willow Ptarmigan	1	22
Sharp-tailed Grouse	12	5
Sora	14	15
American Coot	11	23
Sandhill Crane	40	22
Whooping Crane		1
Black-bellied Plover	3	7
American Golden-Plover	16	16
Semipalmated Plover	10	11
Killdeer	7	26
Greater Yellowlegs	7	10
Lesser Yellowlegs	41	41
Solitary Sandpiper	9	29
Spotted Sandpiper	17	50
Upland Sandpiper	4	3
Whimbrel	7	4
Hudsonian Godwit	1	6
Marbled Godwit	1	
Ruddy Turnstone	1	6
Red Knot		1
Sanderling		5
Semipalmated Sandpiper	9	7
Western Sandpiper	1	1
Least Sandpiper	12	6
White-rumped Sandpiper	3	2
Baird's Sandpiper	1	11
Pectoral Sandpiper	9	6
Stilt Sandpiper	1	4
Buff-breasted Sandpiper	2	9
Short-billed Dowitcher		1
Long-billed Dowitcher	3	1
Wilson's Snipe	35	23
Wilson's Phalarope	1	1

Red-necked Phalarope	11		Bank Swallow	9	39
Parasitic Jaeger		1	Barn Swallow	2	40
Long-tailed Jaeger	1		Cliff Swallow	17	36
Franklin's Gull		3	Black-capped Chickadee		72
Bonaparte's Gull	6	13	Boreal Chickadee	18	58
Mew Gull	41	41	Red-breasted Nuthatch		3
Ring-billed Gull	3	52	Winter Wren		1
California Gull		2	Marsh Wren		3
Herring Gull	40	32	Ruby-crowned Kinglet	37	40
Thayer's Gull		4	Northern Wheatear	1	
Glaucous Gull	3	4	Mountain Bluebird	2	2
Caspian Tern		1	Townsend's Solitaire	3	
Common Tern		10	Gray-cheeked Thrush	6	3
Arctic Tern	1	3	Swainson's Thrush	50	60
Black Tern		11	Hermit Thrush	24	20
Mourning Dove		4	American Robin	61	92
Great Horned Owl	1	5	Varied Thrush	4	4
Northern Hawk Owl	5	6	European Starling		20
Great Gray Owl	2	4	Yellow Wagtail	2	
Long-eared Owl		1	American Pipit	1	10
Short-eared Owl	6	14	Bohemian Waxwing	27	29
Boreal Owl		8	Cedar Waxwing	1	19
Common Nighthawk		11	Tennessee Warbler	24	71
Belted Kingfisher	9	12	Orange-crowned Warbler	37	4
Yellow-bellied Sapsucker	59	36	Yellow Warbler	40	44
Downy Woodpecker		23	Magnolia Warbler	19	36
Hairy Woodpecker	11	88	Cape May Warbler	3	
Three-toed Woodpecker	3	13	Yellow-rumped Warbler	59	54
Black-backed Woodpecker	3	13	Cape May Warbler		8
Northern Flicker	42	39	Palm Warbler	28	12
Pileated Woodpecker		28	Bay-breasted Warbler	1	3
Olive-sided Flycatcher	9	6	Blackpoll Warbler	47	12
Western Wood-Pewee	4	5	Black-and-white Warbler	14	28
Yellow-bellied Flycatcher	6		American Redstart	8	24
Alder Flycatcher	26	46	Ovenbird	2	36
Least Flycatcher	11	43	Northern Waterthrush	35	44
Eastern Phoebe	1	22	Common Yellowthroat	13	40
Say's Phoebe	4	3	Wilson's Warbler	11	8
Eastern Kingbird	10	20	Western Tanager	9	44
Northern Shrike	1	7	American Tree Sparrow	14	30
Blue-headed Vireo		10	Chipping Sparrow	59	77
Warbling Vireo	14	30	Clay-colored Sparrow	7	15
Philadelphia Vireo		1	Savannah Sparrow	33	24
Red-eyed Vireo	9	57	Le Conte's Sparrow	1	8
Gray Jay	55	65	Nelson's Sharp-tailed Sparrow		2
Black-billed Magpie	2	1			
American Crow		29	Fox Sparrow	46	10
Common Raven	62	219	Song Sparrow	3	26
Horned Lark	3	7	Lincoln's Sparrow	44	33
Tree Swallow	40	52	Swamp Sparrow	22	31

White-throated Sparrow	18	88
Harris's Sparrow	3	11
White-crowned Sparrow	62	43
Dark-eyed Junco	58	79
Lapland Longspur	2	8
Snow Bunting	7	29
Rose-breasted Grosbeak		6
Indigo Bunting		1
Red-winged Blackbird	27	48
Western Meadowlark		1
Yellow-headed Blackbird		4
Rusty Blackbird	29	24
Brewer's Blackbird		61
Common Grackle		7
Brown-headed Cowbird	3	17
Gray-crowned Rosy-Finch		4
Pine Grosbeak	17	74
Purple Finch	1	25
House Finch		1
Red Crossbill	1	
White-winged Crossbill	18	5
Common Redpoll	38	62
Hoary Redpoll	4	60
Pine Siskin	6	19
Evening Grosbeak		64
House Sparrow		100

Breeding Bird Surveys

Two Breeding Bird Survey (BBS) routes had been previously established and surveyed near Norman Wells (9 surveys from 1995-2003) and Fort Simpson (7 surveys from 1989-2003). A third BBS route is located at Fort Liard (10 surveys from 1989-2003). These surveys represent 26 survey-years by volunteers and include over 14,000 individual observations. BBS survey methodologies followed North American standards (CWS 2004; Sauer et al. 2004). The BBS routes were located along roadways were surveyed during the breeding season. Each route is approximately 40 km long and each has 50 point count stops that are spaced every 0.8 km. All birds that are heard or seen within a 0.4-km radius of each stop are recorded. Surveys begin 30 minutes before sunrise and normally require 4–5 hours to complete. Weather conditions including cloud cover, wind speed, and temperature, as well as traffic conditions are recorded at the beginning and end of each survey. Surveys are discontinued during periods of weather that inhibit bird song and bird detectability.

For the purpose of understanding and comparing commonality as well as differences in the Mackenzie Valley BBS dataset over time, those species detected on only one route of the three have been excluded from the analysis. Those species recorded in at least two of the three locations are included in relative and yearly mean abundance comparisons as well as described with respect to relative densities and geographic distribution. The measure of species relative abundance was calculated for each location over time and contrasted across the routes. Species yearly mean abundances were calculated for individual species data over the entire survey period (1989-2003) and analysis of variance was compared between the three Mackenzie Valley routes.

Bird densities, habitat and bird community composition

Bird densities were determined for each habitat type by GIS analyses (see GIS Spot mapping data analysis) described above. Bird community compositions were determined by summarizing bird densities by habitat type.

Comparison of historic bird community composition

Historical data for bird densities along the proposed pipeline corridor were compiled from Arctic Gas Pipeline Biological Report Series volumes for ornithological studies that were conducted during 1972-1975. These reports addressed avian communities (songbirds, waterbirds, raptors, etc.) along the length of the Arctic Gas Pipeline[1] from the Mackenzie Delta through the Mackenzie Valley and leading to the Alberta border. To compare historical songbird community composition and densities to current information, data relevant to the 2004 spot mapping study areas at Fort Simpson and Norman Wells were extracted from the reports and compiled using current habitat classifications.

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[1] The Mackenzie transmission pipeline was formally called the Arctic Gas pipeline when the project was first proposed.

Similar bird survey protocols were used each year for historical surveys during 1972-1975 (Salter and Davis 1974). Each year, a series of study sites was selected along the Mackenzie Valley from the air. Due to logistical constraints, study sites that were easily accessible by floatplane were selected, and therefore sites were typically located near lakes or rivers. At each of the study sites, a series of four transects, each being approximately 900 yards (approximately 823 m) long and 20 yards (approximately 18 m) wide were censused. Transects generally followed a rectangular pattern from a pre-selected starting point.

For each survey, two observers would walk the transect lines approximately 20 yards (18 m) apart from one another and record all species detected (by sight or sound) as either 'on transect' if the bird was detected between them, or 'off transect' if the bird was detected elsewhere. Surveyors also noted changes in habitat types along each transect. Surveys were generally conducted between 0800-1500 hrs from late May to mid July of each year. Observers spend approximately 3-4 hrs at each set of transects. Differences in the detectability of different songbird species were not adjusted for in the original data analysis.

Bird surveys were conducted in different areas along the Arctic gasline between 1972-1975. In 1972, surveys were conducted at 23 sites in the southern three quarters of the proposed route that included south of the Mackenzie Delta to the Alberta border (Salter and Davis 1974). Data from 1972 and 1973 surveys provided summaries for each species and habitat type by study site, which allowed for reanalysis of sites relevant to the 2004 study areas near Fort Simpson and Norman Well. Sites MV 15-19 were included in the analysis as they were within 100 km of Norman Wells, and sites MV 5-8 were also included as they were representative of the Fort Simpson area.

In 1973, surveys focussed on eight sites from Norman Wells to the Mackenzie Delta (Tull et al. 1974). The only site relevant to the Norman Wells area was MV 24. In 1974, 24 sites along the entire length of the Mackenzie Valley were surveyed (Ward 1975). Site-specific data were not compiled for these surveys. Instead, the length of the study area was divided into two sections, north and south. Density information from the southern portion of the 1974 study area was used for habitat types relevant to the Fort Simpson and Norman Wells areas. In 1975, surveys were conducted in the Mackenzie Delta (Patterson et al. 1977) and the southern extend of the Mackenzie Valley (Wrigley, NT to the Alberta border) (Wisely and Tull 1975), the latter of which was used for comparison with the 2004 spot mapping plots near Fort Simpson.

In the historical reports, habitat classification was done on the ground while the observers were conducting the bird surveys. The habitat classification was done using a vegetation key (Forsberg 1967) that classified habitats based on structure and vegetation type. The current 2004 habitat classifications were based on landscape level classification through GIS. As a result, the categories used in the historical reports were converted to the current classification scheme (Table 10). Historical categories that did not fit into the current habitat classifications included the following: closed mixed forest, open krumholz, closed mixed forest, open mixed forest, closed evergreen scrub with scattered trees, closed mixed scrub with scattered trees, closed evergreen scrub, closed deciduous scrub with scattered trees and cattail marsh. These habitat types and their corresponding bird communities were dropped from the analysis.

Table 10: List of historical habitat categories from bird surveys conducted between 1972-1975 and their corresponding habitat categories from 2004 spot mapping plots.

Current Habitat Categories (2004)	Historical Habitat Categories (1972-1975)
Black Spruce-Open	Open Spruce Muskeg
	Scattered Spruce Muskeg
	Scattered Spruce - Lichen Muskeg
	Scattered Spruce – Moss Muskeg
	Scattered Spruce - Lichen-Moss Muskeg
Deciduous	Closed Deciduous Forest
	Open Deciduous Forest
Jack Pine	Open Evergreen Forest
Low Shrubland	Closed Evergreen Scrub
	Open Evergreen Scrub
	Closed Deciduous Scrub
	Open Deciduous Scrub
	Open Deciduous Scrub
	Scattered Deciduous Scrub
	Sedge Marsh
Fire Regenerating – Low Shrubland	Closed Deciduous Scrub
	Open Deciduous Scrub
	Scattered Deciduous Scrub
	Open Evergreen Scrub
White Spruce	Closed Evergreen Forest

In the historical reports, bird densities were presented as number of birds/1000 m of transect line. To convert this information into density per hectare, the transect width was assumed to consistently be 20 yards (18 m). The resulting area allowed a density measure of the number of birds per hectare to be calculated. In collating information from 1972 (Salter and Davis 1974) and 1973 (Tull et al. 1974), site-specific information from each of the relevant habitat types was combined, and the number of birds over the entire area sampled (in terms of current habitat classification) was calculated. Site-specific information was not available for 1974 (Ward 1975) and 1975 (Wrigley and Tull 1977). Consequently, the densities by habitat type presented were recalculated into birds per ha for each of the historical habitat categories. A weighted average based on the amount of each historical habitat category sampled within the 2004 categories was then calculated.

In 1974, bird densities <0.5 birds per 1000 yards (approximately 0.3 birds per hectare) were not tabulated in Ward (1975) and not included in the analysis. Overall, densities in each of the current 2004 habitat categories were calculated and compiled in tabular form for each of the sample years for both Fort Simpson and Norman Wells study areas.

Data for birds detected "off" or "outside" the transect or grid were collected each year. Although these detections could not be used to calculate bird densities, they were used to provide useful community composition information. Consequently, habitat specific tallies of all species detected were compiled in tabular form for each survey year.

Bird-habitat correlations

Detrended Correspondence Analysis (DCA) was used to test whether spot mapping plots had bird communities that were representative of their broad habitat categories. DCA was used to analyze all bird species at once by using a multivariate ordination to graphically represent which bird communities were correlated to which habitat types. DCA was also used to determine if there were certain indicator bird species or bird communities that were indicative of particular habitat types. The analysis was used to test how strong of a correlation there was between the broad habitat types of the spot mapping plots, the field observed bird communities and densities, and the corresponding LandSat habitat polygon classifications.

RESULTS

Densities of Birds in 2004: Spot Mapping

Bird densities and species diversity for 2004 spot mapping plots varied depending on habitat types and study area. Overall bird densities were higher for spot mapping plots at the southern study area of Fort Simpson (2.90 pairs per ha) compared to the northern study area of Norman Wells (1.86 pairs per ha) (Table 11). Spot mapping plots did not necessarily sample the same habitat types in each of the two study areas on purpose. Effort was allocated based on an *a priori* analysis of the approximate frequency distribution of habitats along the proposed pipeline in each study area. However, for habitat types that were sampled in both of the 2 study areas, spot mapping plots at Fort Simpson had consistently higher bird densities than those at Norman Wells.

On average, spot mapping plots at Norman Wells had greater species richness (16.5 bird species per plot) than Fort Simpson (13.2 bird species per plot) (Table 12). Two of the three habitat types (black spruce-open and deciduous) that were sampled in both of the two study areas had greater species diversity at Fort Simpson than at Norman Wells. However, the third habitat type (white spruce) that was sampled in both study areas had greater species richness at Norman Wells (22 bird species per plot) than at Fort Simpson (13 bird species per plot).

Table 11: Bird densities by habitat type for spot mapping plots near Fort Simpson and Norman Wells, NT.

Spot Mapping Habitat Type	Bird Density (pairs per ha)		
	Fort Simpson	**Norman Wells**	**Average**
Black Spruce-Open	1.58	1.52	1.55
Deciduous	6.18	2.11	4.15
Fire Regenerating - Low Shrubland	-	1.60	1.60
Jack Pine	1.46	-	1.46
Low Shrubland	2.52	-	2.52
White Spruce	2.75	2.21	2.48
Average	**2.90**	**1.86**	**2.38**

Table 12: Bird species richness by habitat type for spot mapping plots near Fort Simpson and Norman Wells, NT.

Spot Mapping Habitat Type	Number of Different Bird Species		
	Fort Simpson	**Norman Wells**	**Average**
Black Spruce-Open	18	15	16.5
Deciduous	17	9	13.0
Fire Regenerating - Low Shrubland	-	20	20.0
Jack Pine	8	-	8.0
Low Shrubland	10	-	10.0
White Spruce	13	22	17.5
Average	**13.2**	**16.5**	**14.9**

Black spruce-open

Black spruce-open habitats had similar bird densities and species richness for spot mapping plots at both Fort Simpson and Norman Wells. Bird density at Fort Simpson was slightly higher (1.58 pairs per ha) than at Norman Wells (1.52 birds per ha) (Table 11), while species diversity was also marginally higher at Fort Simpson (18 bird species per plot) than Norman Wells (15 bird species per plot) (Table 12). The 6 most abundant bird species were present at both study areas, except for Tennessee Warbler, which was the most abundance bird species at Fort Simpson (0.20 pairs per ha) (Table 13), but absent at Norman Wells (Table 14). In general, black spruce-open habitats had the second lowest bird densities (1.55 pairs per ha), compared to the mean for all habitat types sampled of 2.38 pairs per ha (Table 11).

Table 13: Bird species densities for 4 black spruce-open spot mapping plots near Fort Simpson, NT.

Bird Species 4-letter Code	Bird Species Common Name	Mean Pairs per ha ±SD (n=4)
Black Spruce-Open		
TEWA	Tennessee Warbler	0.20 ±0.14
PAWA	Palm Warbler	0.18 ±0.08
YRWA	Yellow-rumped Warbler	0.18 ±0.14
CHSP	Chipping Sparrow	0.16 ±0.09
RCKI	Ruby-crowned Kinglet	0.16 ±0.12
DEJU	Dark-eyed Junco	0.14 ±0.04
LISP	Lincoln's Sparrow	0.10 ±0.08
SWTH	Swainson's Thrush	0.10 ±0.04
GRJA	Gray Jay	0.08 ±0.0
HETH	Hermit Thrush	0.06 ±0.08
TTWO	Three-toed Woodpecker	0.04 ±0.05
WTSP	White-throated Sparrow	0.04 ±0.05
YBFL	Yellow-bellied Flycatcher	0.04 ±0.05
BOCH	Boreal Chickadee	0.02 ±0.04
CMWA	Cape May Warbler	0.02 ±0.04
LEYE	Lesser Yellowlegs	0.02 ±0.04
PIGR	Pine Grosbeak	0.02 ±0.04
SPGR	Spruce Grouse	0.02 ±0.04

Table 14: Bird species densities for 3 black spruce-open spot mapping plots near Norman Wells, NT.

Bird Species 4-letter Code	Bird Species Common Name	Mean Pairs per ha ±SD (n=3)
Black Spruce –Open		
CHSP	Chipping Sparrow	0.30 ±0.17
PAWA	Palm Warbler	0.19 ±0.19
DEJU	Dark-eyed Junco	0.14 ±0.05
SWTH	Swainson's Thrush	0.14 ±0.17
YRWA	Yellow-rumped Warbler	0.14 ±0.05
LISP	Lincoln's Sparrow	0.11 ±0.12
OCWA	Orange-crowned Warbler	0.11 ±0.05
BPLW	Blackpoll Warbler	0.08 ±0.05
GRJA	Gray Jay	0.08
HETH	Hermit Thrush	0.08
AMRO	American Robin	0.03 ±0.05
BOWX	Bohemian Waxwing	0.03 ±0.05
PIGR	Pine Grosbeak	0.03 ±0.05
RCKI	Ruby-crowned Kinglet	0.03 ±0.05
WCSP	White-crowned Sparrow	0.03 ±0.05

Deciduous

Deciduous habitats had bird densities and species diversity that were higher for spot mapping plots at Fort Simpson than at Norman Wells. Deciduous spot mapping plots at Fort Simpson had 17 bird species recorded, compared to only 9 species at Norman Wells (Table 12), or 47% fewer species than Fort Simpson. Deciduous plots at Fort Simpson had 11 species (64.7%) that were absent from deciduous plots at Norman Wells. Deciduous plots at Norman Wells had only 3 species (33.3%) that were not recorded at Fort Simpson. The greater species diversity at Fort Simpson deciduous plots may suggest that the breeding ranges of some bird species associated with deciduous habitat types do not extend as far north as Norman Wells.

Mean species densities were notably higher at Fort Simpson deciduous plots than at Norman Wells, particularly for Least Flycatcher (1.55 pairs per ha), Red-eyed Vireo (0.90 pairs per ha), Yellow-bellied Sapsuckers (0.90 pairs per ha), and Ovenbird (0.65 pairs per ha) (Table 15), species that were absent from Norman Wells deciduous plots (Table 16). Overall mean bird densities for deciduous plots at Fort Simpson (6.18 pairs per ha) were nearly 3 times greater than those of Norman Wells (2.11 pairs per ha) (Table 11).

Table 15: Bird species densities for 1 deciduous spot mapping plot near Fort Simpson, NT.

Bird Species 4-letter Code	Bird Species Common Name	Mean Pairs per ha ±SD (n=1)
Deciduous		
LEFL	Least Flycatcher	1.55
REVI	Red-eyed Vireo	0.90
TEWA	Tennessee Warbler	0.90
YBSA	Yellow-bellied Sapsucker	0.90
OVEN	Ovenbird	0.65
BAWW	Black-and-white Warbler	0.16
SWTH	Swainson's Thrush	0.16
WAVI	Warbling Vireo	0.16
YRWA	Yellow-rumped Warbler	0.16
AMRE	American Redstart	0.08
AMRO	American Robin	0.08
DOWO	Downy Woodpecker	0.08
FOSP	Fox Sparrow	0.08
MAGW	Magnolia Warbler	0.08
NOWA	Northern Waterthrush	0.08
RUGR	Ruffed Grouse	0.08
WETA	Western Tanager	0.08

Table 16: Bird species densities for 1 deciduous spot mapping plot near Norman Wells, NT.

Bird Species 4-letter Code	Bird Species Common Name	Mean Pairs per ha ±SD (n=1)
Deciduous		
OCWA	Orange-crowned Warbler	0.49
SWTH	Swainson's Thrush	0.49
YRWA	Yellow-rumped Warbler	0.41
WAVI	Warbling Vireo	0.24
BAWW	Black-and-white Warbler	0.16
CHSP	Chipping Sparrow	0.08
DEJU	Dark-eyed Junco	0.08
MAGW	Magnolia Warbler	0.08
TEWA	Tennessee Warbler	0.08

Fire regenerating - low shrubland

Fire regenerating-low shrubland habitats were only sampled at Norman Wells. Five spot mapping plots of fire-regeneration-low shrubland habitat were sampled, which may explain the relatively high species diversity (20 bird species per plot) for this habitat type (Table 12). Bird density (1.60 pairs per ha) was the third lowest among habitat types sampled (Table 11). The top 4 most abundant bird species in fire regenerating-low shrubland habitats were sparrows: Lincoln's Sparrow (0.42 pairs per ha), White-crowned Sparrow (0.41 pairs per ha), Chipping Sparrow (0.20 pairs per ha), and Clay-colored Sparrow (0.11 pairs per ha) (Table 17). Three other sparrow species were also recorded in this habitat type: Fox Sparrow, Savannah Sparrow, and Swamp Sparrow all with densities of 0.03 pairs per ha.

Table 17: Bird species densities for 5 fire regenerating-low shrubland spot mapping plot near Norman Wells, NT.

Bird Species 4-letter Code	Bird Species Common Name	Mean Pairs per ha ±SD (n=5)
Fire regenerating-Low Shrubland		
LISP	Lincoln's Sparrow	0.42 ±0.27
WCSP	White-crowned Sparrow	0.41 ±0.06
CHSP	Chipping Sparrow	0.20 ±0.16
CCSP	Clay-colored Sparrow	0.11 ±0.16
ALFL	Alder Flycatcher	0.07 ±0.07
OCWA	Orange-crowned Warbler	0.05 ±0.11
BPLW	Blackpoll Warbler	0.03 ±0.07
FOSP	Fox Sparrow	0.03 ±0.04
LEYE	Lesser Yellowlegs	0.03 ±0.04

NOWA	Northern Waterthrush	0.03 ±0.04
SAVS	Savannah Sparrow	0.03 ±0.18
SWSP	Swamp Sparrow	0.03 ±0.07
CORE	Common Redpoll	0.02 ±0.04
DEJU	Dark-eyed Junco	0.02 ±0.04
HAWO	Hairy Woodpecker	0.02 ±0.04
HETH	Hermit Thrush	0.02 ±0.04
PAWA	Palm Warbler	0.02 ±0.04
STGR	Sharp-tailed Grouse	0.02 ±0.04
TRES	Tree Swallow	0.02 ±0.04
WISN	Wilson's Snipe	0.02 ±0.04

White spruce

White spruce habitats had similar bird densities for spot mapping plots at Fort Simpson (2.75 pairs per ha) and Norman Wells (2.21 pairs per ha) (Table 11), but notably higher species diversity at Norman Wells (22 bird species per plot) compared to Fort Simpson (13 bird species per plot) (Table 12). The overall greater species diversity for white spruce habitats at Norman Wells may be influenced by the 3 spot mapping plots that were sampled at Norman Wells compared to the single plot at Fort Simpson. The high densities of Yellow-bellied Sapsuckers (0.41 pairs per ha) and Ovenbirds (0.16 pairs per ha) that were recorded at Fort Simpson (Table 18), but nearly absent from Norman Wells (Table 19), may be due in part to the higher proportion of trembling aspen found at the Fort Simpson plot (Table 3), or the breeding densities of these two species becoming more sparse further north towards Norman Wells.

Table 18: Bird species densities for 1 white spruce spot mapping plot near Fort Simpson, NT.

Bird Species 4-letter Code	Bird Species Common Name	Mean Pairs per ha ±SD (n=1)
White Spruce		
TEWA	Tennessee Warbler	0.73
CHSP	Chipping Sparrow	0.41
YBSA	Yellow-bellied Sapsucker	0.41
YRWA	Yellow-rumped Warbler	0.24
OVEN	Ovenbird	0.16
SWTH	Swainson's Thrush	0.16
WETA	Western Tanager	0.16
AMRO	American Robin	0.08
BBWA	Bay-breasted Warbler	0.08
CMWA	Cape May Warbler	0.08
DEJU	Dark-eyed Junco	0.08
MAGW	Magnolia Warbler	0.08
RCKI	Ruby-crowned Kinglet	0.08

Table 19: Bird species densities for 3 white spruce spot mapping plot near Norman Wells, NT.

Bird Species 4-letter Code	Bird Species Common Name	Mean Pairs per ha ±SD (n=3)
White Spruce		
SWTH	Swainson's Thrush	0.30 ±0.17
DEJU	Dark-eyed Junco	0.22 ±0.12
TEWA	Tennessee Warbler	0.22 ±0.24
YRWA	Yellow-rumped Warbler	0.22 ±0.12
CHSP	Chipping Sparrow	0.19 ±0.09
OCWA	Orange-crowned Warbler	0.16 ±0.08
BPLW	Blackpoll Warbler	0.14 ±0.12
MAGW	Magnolia Warbler	0.14 ±0.24
PAWA	Palm Warbler	0.11 ±0.12
HETH	Hermit Thrush	0.08 ±0.08
RCKI	Ruby-crowned Kinglet	0.08 ±0.08
GRJA	Gray Jay	0.05 ±0.05
BAWW	Black-and-white Warbler	0.03 ±0.05
BOCH	Boreal Chickadee	0.03 ±0.05
BOWX	Bohemian Waxwing	0.03 ±0.05
FOSP	Fox Sparrow	0.03 ±0.05
LISP	Lincoln's Sparrow	0.03 ±0.05
PIGR	Pine Grosbeak	0.03 ±0.05
WAVI	Warbling Vireo	0.03 ±0.05
WCSP	White-crowned Sparrow	0.03 ±0.05
WETA	Western Tanager	0.03 ±0.05
YBSA	Yellow-bellied Sapsucker	0.03 ±0.05

Jack pine

Jack pine habitats were only sampled at Fort Simpson and had the lowest bird densities (1.46 pairs per ha) (Table 11) and species diversity (8 bird species per plot) (Table 12) of all habitat types sampled. The two most abundant bird species in jack pine habitats were warblers: Ovenbird (0.41 pairs per ha) and Tennessee Warbler (0.33 pairs per ha) (**Table 20**). Six other bird species were recorded in jack pine habitats, including Blue-headed Vireo (0.08 pairs per ha), which was not recorded for any other habitat type in the two study areas.

Table 20: Bird species densities for 1 jack pine spot mapping plot near Fort Simpson, NT.

Bird Species 4-letter Code	Bird Species Common Name	Mean Pairs per ha ±SD (n=1)
Jack pine		
OVEN	Ovenbird	0.41
TEWA	Tennessee Warbler	0.33
CHSP	Chipping Sparrow	0.16
SWTH	Swainson's Thrush	0.16
YRWA	Yellow-rumped Warbler	0.16
BAWW	Black-and-white Warbler	0.08
BHVI	Blue-headed Vireo	0.08
HETH	Hermit Thrush	0.08

Low shrublands

Low shrubland habitats were only sampled at Fort Simpson had the second highest bird density (2.52 pairs per ha) (Table 11) and the second lowest species diversity (10 bird species per plot) (Table 12). Similar to fire regenerating-low shrubland habitats sampled at Norman Wells, sparrows comprised 4 of the 5 most abundant species in low shrubland habitats: Swamp Sparrow (0.65 pairs per ha), Clay-colored Sparrow (0.49 pairs per ha), Common Yellowthroat (0.49 pairs per ha), Lincoln's Sparrow (0.33 pairs per ha), and LeConte's Sparrow (0.16 pairs per ha) (Table 21). Sixty percent of all species detected in low shrubland habitats were sparrows. Overall species diversity was half of that recorded in fire regenerating-low shrubland habitat plots, however, this may be due in part to 5 plots being sampled for fire regenerating-low shrubland habitats and only 1 plot for low shrubland habitat.

Table 21: Bird species densities for 1 low shrubland spot mapping plot near Fort Simpson, NT.

Bird Species 4-letter Code	Bird Species Common Name	Mean Pairs per ha ±SD (n=1)
Low Shrubland		
SWSP	Swamp Sparrow	0.65
CCSP	Clay-colored Sparrow	0.49
COYE	Common Yellowthroat	0.49
LISP	Lincoln's Sparrow	0.33
LCSP	LeConte's Sparrow	0.16
ALFL	Alder Flycatcher	0.08
AMRO	American Robin	0.08
CHSP	Chipping Sparrow	0.08
TEWA	Tennessee Warbler	0.08
WTSP	White-throated Sparrow	0.08

Other data

Several bird species were detected during spot map surveys but were determined to be *off-grid* and were not included in density calculations. These data are listed in Appendix 6 and 7. Other species were detected as *fly-overs*, with no obvious connection to the study plot. These species are listed in Appendix 8.

Habitat and breeding bird community relationships

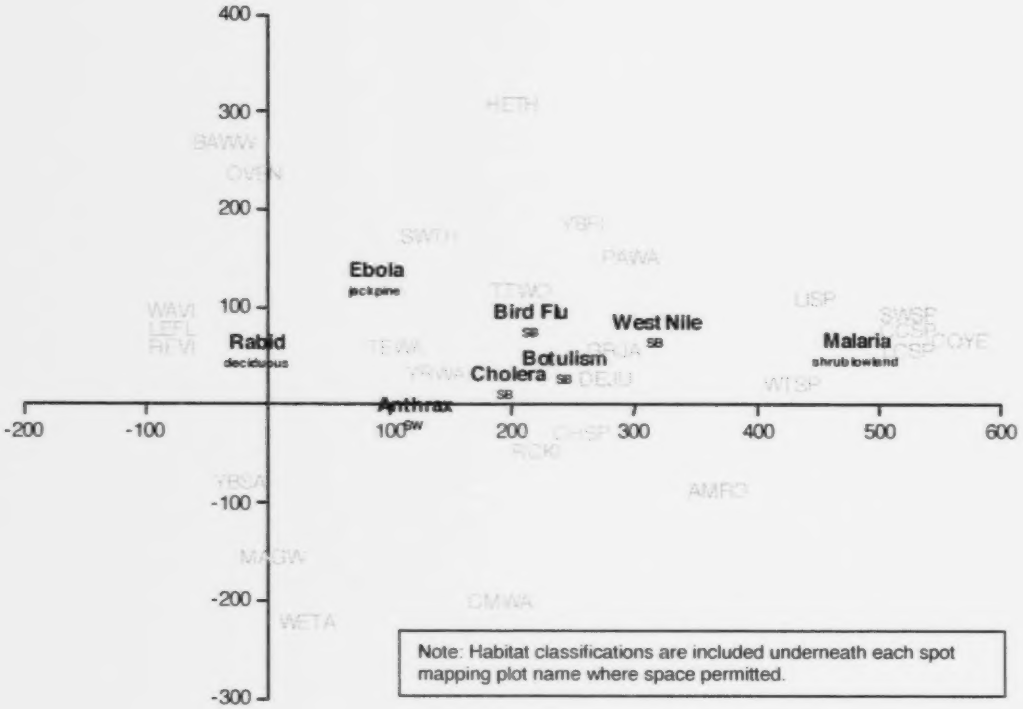
DCA analyses were done to compare bird community structure among grids (habitat types). These analyses show that bird communities appear to cluster based on assigned habitat classifications for each grid, similar to the way vegetation communities clustered (Figure 6 and Figure 7).

Fort Simpson – Bird communities within each habitat type show a gradient from shrubland communities (e.g. Malaria), through black spruce communities (e.g. West Nile, Botulism, Cholera, Bird Flu) to deciduous communities (e.g. Rabid).

Shrubland bird communities were defined most by the following species:
-WTSP, LISP, SWSP, CCSP, LCSP, and COYE.
Black spruce communities were defined most by:
-DEJU, GRJA, TTWO, RCKI, CHSP, and YRWA.
Deciduous communities were defined by species such as
- WAVI, LEFL, and REVI.

Norman Wells – Bird communities in Norman Wells showed a separation based on habitat type similar to Fort Simpson areas. The DCA graph (Figure 2) for this region shows a clear community gradient from open burn areas (e.g. Burns 1-4), through black spruce areas (e.g. Vermillion, Meteo 1-2), to deciduous communities (e.g. Deciduous).

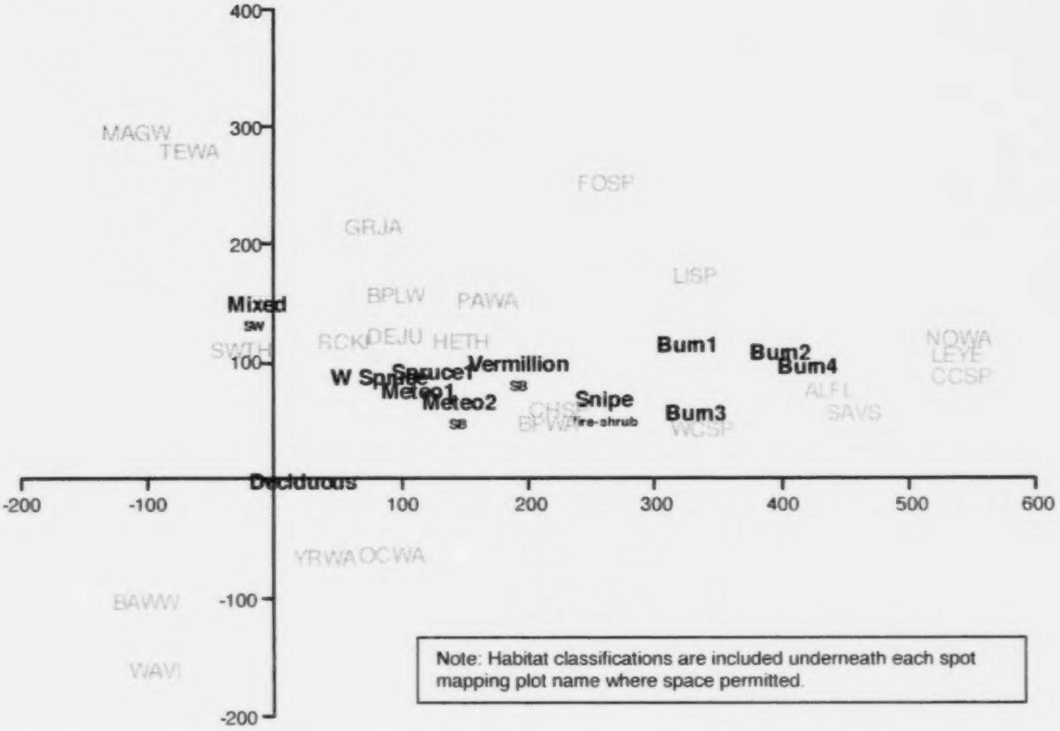
Burn bird communities were defined most by the following species:
-NOWA, LEYE, CCSP, ALFL and SAVS.
Black spruce communities were defined by species such as:
-CHSP, HETH, BPWA, DEJU, and RCKI.
Deciduous communities were defined by species such as:
-BAWW, WAVI and YRWA.
Mixed-spruce communities were defined most by:
-TEWA, SWTH, and MAGW.



Note: Habitat classifications are included underneath each spot mapping plot name where space permitted.

* See Appendix 1 for a list of bird species names and codes.

Figure 6: Detrended Correspondence Analysis graph for bird communities by 2004 spot mapping plots near Fort Simpson, NT.



Note: Habitat classifications are included underneath each spot mapping plot name where space permitted.

* See Appendix 1 for a list of bird species names and codes.

Figure 7: Detrended Correspondence Analysis graph for bird communities by 2004 spot mapping plots near Norman Wells, NT.

Breeding Bird Surveys (1990s to 2003)

Seventy-three songbird species were recorded during the BBS over the entire survey period (1989-2004) at three locations in the Mackenzie Valley, NWT (Table 22). Fifty-three species were detected in at least two of the three routes over the survey period, 26 species were detected at least once at all three locations, and nine species were consistently recorded each year on all three routes. Of the 53 species detected on at least two of the three sites, 32 species were commonly (detected >50% of years surveyed) recorded, 14 were relatively common and seven were uncommon (detected <25% of years on all routes).

Of the 32 species commonly recorded, Swainson's Thrush (comprising 11.9% of all individuals detected) and Tennessee Warbler (11.3%) were numerically dominant in the dataset, followed by, Chipping Sparrow (7.3%), Alder Flycatcher (6.2%), Yellow-rumped Warbler (6.0%), White-throated Sparrow (5.2%), Magnolia Warbler (4.4%), Red-eyed Vireo (4.2%), American Robin (4.1%), and Ovenbird (3.3%) (Figure 8). These ten species represented 64% of the Mackenzie Valley songbird detections and nearly 9,000 observations over the entire BBS survey period (1989-2003).

Table 22. Birds detected during BBS in the NWT.

Norman Wells			Fort Simpson			Fort Liard		
Species[1]	**n[2]**	**mean[3]**	**Species[1]**	**n[2]**	**mean[3]**	**Species[1]**	**n[2]**	**mean[3]**
CHSP	9	37.9	TEWA	7	83.4	TEWA	10	94.2
YRWA	9	36.8	SWTH	7	58.9	SWTH	10	59.8
AMRO	9	32.4	YRWA	7	44.9	ALFL	10	49.8
LISP	9	24.7	CHSP	7	42.9	WTSP	10	46.4
ALFL	9	21.3	WWCR	5	38.0	MAGW	10	40.3
DEJU	9	19.8	REVI	7	29.6	REVI	10	36.8
OCWA	9	17.9	MAGW	7	28.3	CHSP	10	36.2
HETH	9	16.6	ALFL	7	23.4	OVEN	10	30.7
RCKI	9	12.1	WTSP	7	23.1	AMRE	10	21.6
GRJA	9	11.2	OVEN	7	20.6	LEFL	10	21.2
FOSP	9	10.4	AMRO	7	18.7	YRWA	9	18.0
WTSP	9	10.2	LEFL	7	17.9	FOSP	10	17.0
PAWA	8	8.6	RCKI	7	17.9	WAVI	10	15.2
BPWA	9	8.2	WAVI	7	17.3	LISP	10	14.4
SWTH	9	6.9	GRJA	7	13.7	AMRO	10	14.3
WWCR	7	6.9	DEJU	7	13.1	WETA	10	10.4
SWSP	9	5.1	WETA	7	12.1	PISI	7	9.9
YWAR	7	3.9	HETH	7	11.7	RBGR	10	9.8
CORE	8	3.8	RWBL	7	6.4	DEJU	10	8.9
TEWA	6	3.0	LISP	7	5.9	GRJA	10	8.4
VATH	7	1.7	BAWW	7	5.6	BAWW	7	7.9
COYE	8	1.6	AMRE	6	5.3	NOWA	10	7.0
TRES	5	1.1	NOWA	7	5.1	WWCR	7	6.3
OSFL	4	0.8	BHVI	6	3.9	YBFL	6	5.3
MAGW	4	0.8	CMWA	4	3.9	RCKI	10	5.1
BOCH	5	0.8	BOWA	5	3.4	HETH	9	4.7
BOWA	3	0.7	FOSP	6	3.4	RBNU	8	3.2
CORA	4	0.7	COYE	7	3.3	BARS	5	2.8
WAVI	3	0.6	TRES	7	3.0	CORE	3	2.5
NOWA	3	0.6	PISI	4	2.7	SWSP	9	2.2
RWBL	4	0.6	CORA	7	2.6	COYE	8	2.0
REVI	3	0.4	CORE	2	2.6	CAWA	5	1.7
LEFL	2	0.3	BPWA	4	2.3	BHVI	6	1.6
EAKI	3	0.3	OCWA	4	1.9	WWPE	6	1.4
WETA	1	0.2	PAWA	5	1.7	BCCH	7	1.4
CCSP	1	0.1	SWSP	6	1.7	VATH	3	1.3
PISI	1	0.1	OSFL	5	1.4	CMWA	4	1.2
WWPE	0	0.0	EAPH	5	1.4	PAWA	4	1.2
YBFL	0	0.0	BARS	6	1.3	CORA	5	0.9
EAPH	0	0.0	WWPE	3	0.7	TRES	6	0.9

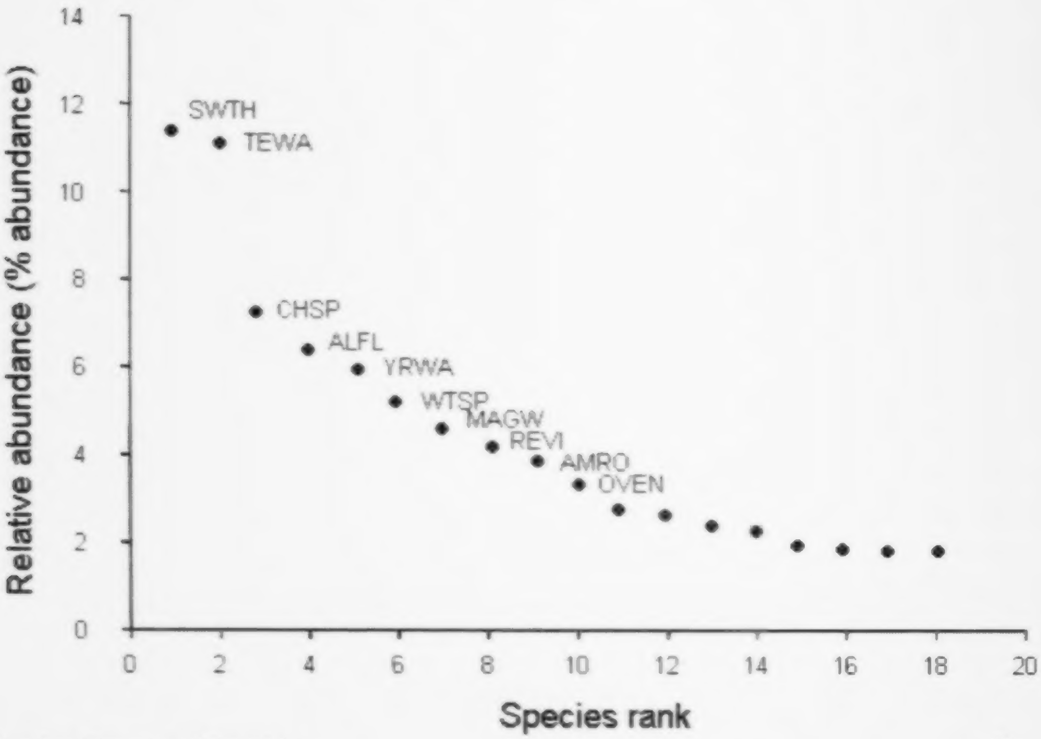
Norman Wells			Fort Simpson			Fort Liard		
Species[1]	**n**[2]	**mean**[3]	**Species**[1]	**n**[2]	**mean**[3]	**Species**[1]	**n**[2]	**mean**[3]
BHVI	0	0.0	YBFL	3	0.7	YWAR	6	0.8
AMCR	0	0.0	RBNU	4	0.7	BOCH	5	0.7
BARS	0	0.0	RBGR	3	0.7	EAPH	3	0.6
BCCH	0	0.0	BOCH	3	0.4	OCWA	5	0.6
RBNU	0	0.0	EAKI	2	0.3	BPWA	3	0.6
CMWA	0	0.0	YWAR	1	0.3	ATSP	1	0.6
BAWW	0	0.0	AMCR	1	0.1	BOWA	3	0.5
AMRE	0	0.0	VATH	1	0.1	CCSP	2	0.3
OVEN	0	0.0	CAWA	1	0.1	LESP	1	0.3
CAWA	0	0.0	ATSP	1	0.1	RWBL	3	0.3
ATSP	0	0.0	LESP	1	0.1	OSFL	1	0.1
LESP	0	0.0	SOSP	1	0.1	AMCR	1	0.1
SOSP	0	0.0	BCCH	0	0.0	SOSP	1	0.1
RBGR	0	0.0	CCSP	0	0.0	EAKI	0	0.0

[1] See Appendix 1 and 2 for full names

[2] n=number of years BBS has been conducted

[3] mean number of birds detected/survey/year

Figure 8. Songbird species relative abundance found on Mackenzie Valley breeding bird survey (BBS) routes over the entire survey period (1989-2003). Species greater than 3% relative abundance are labelled. See Appendix 1 and 2 for species codes.



Uncommon species in the Mackenzie Valley were mainly songbirds detected at the northern limit of their geographic range and included, Eastern Kingbird, American Crow, Canada Warbler, American Tree Sparrow, Clay-coloured Sparrow, Le Conte's Sparrow, and Song Sparrow. The majority of single-route-recorded species were detected at Fort Liard, which had 11 species that were not detected at any other Mackenzie Valley location. These species were excluded from the analysis (Table 23).

Table 23. List of single-route-recorded species. Route location[a] in parentheses:

Hammond's Flycatcher (FL)	Connecticut Warbler (FL)
Philadelphia Vireo (FL)	Mourning Warbler (FL)
Bank Swallow (FS)	MacGillivray's Warbler (FL)
Cliff Swallow (FS)	Wilson's Warbler (NW)
Black-capped Chickadee (FL)	Savannah Sparrow (NW)
Winter Wren (FL)	Harris's Sparrow (NW)
Golden-crowned Kinglet (FL)	Brown-headed Cowbird (NW)
Gray-cheeked Thrush (NW)	Pine Grosbeak (NW)
Cedar Waxwing (FS)	Evening Grosbeak (FL)
Bay-breasted Warbler (FL)	Red Crossbill (FL)

[a] Fort Liard (FL); Fort Simpson (FS); and Norman Wells (NW).

The greatest mean abundance was 646 birds/year calculated during the three most recent years (2001-2003) at Fort Simpson. The first four years at Fort Liard (Table 24), recorded a similarly high abundance of 644 birds/year, an abundance comparable to the most recent five years of data collected at Fort Liard during which the mean yearly abundance was 635 birds/year. Data from Fort Simpson (2001-2003) suggested an increase in abundance has occurred since the first four years (1989-1992) when the mean abundance was 577 birds/year (Table 25). The lowest yearly abundance was recorded at Norman Wells (324 birds/year). A comparison of the first four years of BBS data at Norman Wells (1995-1998) with the most recent five years (1999-2003) also suggests an increase in mean yearly abundance has occurred (324 birds/year vs. 464 birds/year; respectively).

Table 24. Relative abundance of eight most common songbird species detected at Fort Liard. See Appendix 1 and 2 for species codes.

Fort Liard (1989-1992)		Fort Liard (1998-2003)	
Mean abundance: 644 birds/year		Mean abundance: 635 birds/year	
TEWA	13.4%	TEWA	15.7%
ALFL	11.4%	SWTH	8.8%
SWTH	10.2%	WTSP	6.9%
WTSP	7.8%	MAGW	6.8%
REVI	6.7%	CHSP	6.4%
MAGW	5.5%	OVEN	5.6%
CHSP	4.6%	ALFL	5.4%
OVEN	3.6%	REVI	5.1%

Table 25. Relative abundance of eight most common songbird species detected at Fort Simpson and Norman Wells. See Appendix 1 and 2 for species codes

Fort Simpson (1989-1992)		Norman Wells (1995-1998)	
Mean abundance: 577 birds/year		Mean abundance: 324 birds/year	
TEWA	10.5%	SWTH	18.0%
SWTH	10.2%	CHSP	12.8%
WWCR	9.0%	AMRO	9.9%
CHSP	7.1%	LISP	8.3%
YRWA	6.7%	WCSP	6.9%
REVI	5.5%	YRWA	6.7%
ALFL	5.1%	ALFL	5.8%
MAGW	3.9%	DEJU	5.3%
Fort Simpson (2001-2003)		Norman Wells (1999-2003)	
Mean abundance: 646 birds/year		Mean abundance: 464 birds/yr.	
TEWA	17.6%	SWTH	16.7%
SWTH	9.1%	YRWA	10.5%
YRWA	8.2%	CHSP	7.5%
CHSP	7.0%	AMRO	7.1%
MAGW	5.6%	WCSP	5.5%
WTSP	4.6%	OCWA	5.1%
OVEN	4.3%	ALFL	5.0%
REVI	4.1%	LISP	4.9%

Comparisons of total songbird species abundance across each of the BBS routes revealed several notable differences. Firstly, the relative abundance calculated for each route showed differences in the species rank of the most common species. A direct comparison of relative abundances of most common species between routes and over time demonstrated differing trends of songbird species populations; and, analysis of songbird mean yearly abundance showed dissimilarities of routes and suggested limits of geographic distribution for several songbird species.

Tennessee warbler (TEWA) ranked number one among the common species on the Fort Liard and Fort Simpson routes with a greatest relative abundance calculated over time on these two routes. The predominance of TEWA at Fort Liard and Fort Simpson is most apparent in more recent BBS data (1998-2003) when TEWA relative abundance was nearly twice as great as the next most relative abundant species. Furthermore, TEWA demonstrated an increasing relative abundance over time on both these routes. The relative abundance increased from 13.4% (1989-1992) to 15.7% (1998-2003) at Fort Liard, and from 10.5% (1989-1992) to 17.6% (2001-2003) at Fort Simpson. On the Norman Wells route, however, only occasional detections of TEWA were made.

The next most relative abundant species was Swainson's Thrush (SWTH), which was the only species consistently in the top three most common species on [illegible] routes. SWTH was the predominant songbird detected on the Norman Wells route an[illegible]ly outnumbered by TEWA during recent years on both Fort Liard and Fort Simpson routes. Despite high densities on all routes SWTH has consistently demonstrated a decreasing trend in its population abundance. SWTH relative abundance decreased over time from 10.2% relative abundance (1989-1992) on both Fort Liard and Fort Simpson routes to 8.8% (1998-2003, FL) and 9.1% (2001-2003, FS), respectively. SWTH relative abundance also decreased at Norman Wells from 18.0% (1995-1998) to 16.7% (1999-2003).

The third ranked species overall was Chipping Sparrow (CHSP), which ranked between seventh (4.6%) at Fort Liard (1989-1992) and second (12.8%) at Norman Wells (1995-1998). CHSP showed a range of relative abundance changes over time and locations in the Mackenzie Valley. CHSP increased from 4.6% relative abundance (1989-1992) to 6.4% (1998-2003) on the Fort Liard route; demonstrated a decreased relative abundance trends at Norman Wells from 12.8% (1995-1998) to 7.5% (1999-2003); and, suggested a relatively stable abundance (7.0%) on the Fort Simpson route.

Alder Flycatcher (ALFL), the fourth ranked species, was the only other species to have a recorded relative abundance greater than SWTH (1989-1992; Fort Liard). Among the most common on all routes, this species demonstrated the greatest decrease in relative abundance over time. The most apparent decrease in ALFL relative abundance was seen at Fort Liard where a 6.0% drop in relative abundance was observed between the 1989-1992 and 1998-2003 BBS survey periods. At Fort Simpson, ALFL relative abundance decreased from 5.1% (1989-1992) to 2.4% relative abundance (2001-2003). On the Norman Wells route, ALFL demonstrated a slight decrease from 5.8% (1995-1998) to 5.0% between 1999 and 2003.

The next most common species was Yellow-rumped Warbler (YRWA). This species ranked third most relative abundant species at Fort Simpson (2001-2003) and second on the Norman Wells route (1999-2003). On both these routes, YRWA has demonstrated an increased relative abundance in recent years. YRWA relative abundance increased from 6.7% (1989-1992) to 8.2% (2001-2003) at Fort Simpson and from 6.7% (1995-1998) to 10.5% (1999-2003) on the Norman Wells route.

Among the remaining top ten most common species, two species (MAGW and OVEN), have apparently increased in relative abundance, two species (REVI and AMRO), have declined and one (WTSP) has demonstrated both an increased and a decreased population relative abundance trend on Mackenzie Valley BBS routes.

Among the 53 species that were detected on at least two of the three BBS routes, 28 species showed evidence of significantly different yearly mean abundances (Appendix 15). The Fort Liard route had the greatest number of most abundant species with nine, followed by the Norman Wells route, which had seven species with significantly greater abundance than on either of the other two routes. Two species had significantly greater yearly mean abundances on the Fort Simpson route (CORA and RWBL). Ten species revealed similarly significant greater yearly mean abundances on two of the three routes. Seven species had similarly higher yearly abundances on both Fort Liard and Fort Simpson, and three species shared a significantly greater mean abundance on Norman Wells and Fort Simpson routes. Fort Simpson and Fort Liard routes each recorded all but one of the 53 species; at Norman Wells 16 species were not recorded.

Comparison of historical (1970s) bird community composition and densities to 2004 spot map surveys

Data from Fort Simpson and Norman Wells were compared for bird community composition and species densities between historical data collected in the 1970s (Appendices 9-13) and data from 2004 spot mapping plots. Comparisons for bird community composition and species densities were made for each six habitat types sampled for the study. Comparisons for bird community composition included all bird detection data collected along (both on and off) transect lines from the 1970s surveys and all bird detection data from (both on and off grid) 2004 spot mapping plots. For species densities comparisons, only data from "on" transect lines for the 1970s and "on grid" data from spot mapping plots for 2004 were used.

Black spruce-open

Community Composition

Black spruce-open habitats were sampled at both Fort Simpson and Norman Wells. In general, the southern Fort Simpson study sites had greater species diversity, both historically and currently, than the more northern Norman Wells study sites. In both study areas, the species composition appeared to change somewhat since the 1972-1975 surveys.

At Fort Simpson, 24 species were detected during historical surveys, while 38 species were detected in 2004 for black spruce-open habitats (Table 26). Of nine species that were commonly detected during the historical surveys, only one (Red-winged Blackbird) was absent in 2004. However, there were seven species detected in 2004 that were not detected during the 1970s surveys, indicating higher songbird diversity in 2004 than historically.

Table 26: Current and historical bird community composition in black spruce-open forest habitat near Fort Simpson, NT.

Bird Species	2004	1972	1975	Bird Species	2004	1972	1975
ALFL	*	*		PISI			
AMRO	*			PUFI	*		
BAWW	*			RBNU	*		
BHVI	*			RCKI	*	*	
BOCH	*		*	REVI			*
BPLW		*		RUBL	*		
CHSP	*	*	*	RWBL		*	*
CMWA	*			SACR	*		
COYE		*		SORA	*		
DEJU	*	*	*	SOSP	*		*
EAKI		*		SPGR	*		
FOSP	*			SWSP	*		*
GRJA	*	*	*	SWTH	*	*	*
HETH	*		*	TESW		*	
LEYE	*	*	*	TEWA	*		*
LISP	*	*	*	TTWO	*		
MAGW	*			WETA	*		
NHOW	*			WISN	*		
NOFL	*			WTSP	*	*	
NOWA	*			WWCR			*
OSFL	*	*		YBFL	*		
PAWA	*	*	*	YBSA	*		
PIGR	*			YRWA	*	*	*
				Total # Species	**38**	**17**	**16**

* Species detected both "on" and/or "off" survey transects (1970s) or survey plots (2004); see Appendix 1 for bird species codes and names.

At Norman Wells, 32 bird species were detected during 1970s surveys, while 19 species were detected in 2004 for black spruce-open habitats (Table 27). Six of the 15 species that were consistently detected during historical surveys were not detected in 2004, while two species were present in 2004 that were not detected during historical surveys.

Table 27: Current and historical bird community composition in black spruce-open forest habitat near Norman Wells, NT.

Bird Species	**2004**	**1972**	**1973**	**1974**	**Bird Species**	**2004**	**1972**	**1973**	**1974**
ALFL		*			NOFL	*	*		
AMRE				*	NOWA			*	
AMRO	*	*	*	*	OCWA	*			
ATSP		*			PAWA	*	*		*
BANS				*	PIGR	*			*
BHVI				*	PISI				*
BOWX	*	*	*	*	RCKI	*	*		
BPLW	*	*	*	*	RUBL		*	*	*
CHSP	*	*	*	*	SACR	*			
CORE		*	*	*	SAVS		*		*
DEJU	*			*	SWTH	*	*	*	*
FOSP				*	TESW		*		*
GCTH		*		*	TEWA		*		*
GRJA	*	*	*	*	VATH				*
HASP				*	WCSP	*			*
HETH	*			*	WWCR	*	*		*
LISP	*			*	YBFL	*			
					YRWA	*	*	*	*
					Total # Species	**19**	**19**	**10**	**27**

* Species detected both "on" and/or "off" survey transects (1970s) or survey plots (2004); see Appendix 2 for bird species codes and names.

Species Densities

At Fort Simpson, 18 bird species were detected in 2004 for black spruce-open habitats, while 19 species were detected during 1970s surveys (Table 28). Eleven of these species occurred during both sampling periods, allowing for density comparisons. Four species had lower densities in 2004, 6 species remained unchanged, and 1 species increased in density compared to historical levels. Chipping Sparrow was among the most common species in both periods, while Tennessee Warbler, Yellow-rumped Warbler, and Palm Warbler were among the most common in 2004. In contrast, Gray Jay, Red-winged Blackbird and Swainson's Thrush were more common in the 1970s.

Table 28: Current and historical bird densities for black spruce-open habitat near Fort Simpson, NT. The area of habitat surveyed in 2004 = 49 ha.

Species	2004 Average Individuals/Ha±SD (n)	1972 Average Individuals/Ha	1974 Average Individuals/Ha	1975 Average Individuals/Ha
		12.6 Ha sampled	*86.2 Ha Sampled*	*42.6 Ha Sampled*
ALFL	-	0.08	-	-
BOCH	0.02 ±0.04(4)	-	-	0.02
CHSP	0.16 ±0.09(4)	0.79	0.64	0.44
CMWA	0.02 ±0.04(4)	-	-	-
DEJU	0.14 ±0.04(4)	-	0.29	0.38
EAKI	-	0.08	-	-
GRJA	0.08 ±0.0(4)	0.24	0.98	0.25
HETH	0.06 ±0.08(4)	-	-	0.02
LEYE	0.02 ±0.04(4)	-	-	-
LISP	0.10 ±0.08(4)	0.08	-	0.06
PAWA	0.18 ±0.08(4)	0.08	-	-
PIGR	0.02 ±0.04(4)	-	-	-
PISI	-	-	0.1	-
RCKI	0.16 ±0.12(4)	-	-	-
RUBL	-	-	-	0.14
RWBL	-	0.32	-	0.05
SPGR	0.02 ±0.04(4)	-	-	-
SWSP	-	-	-	0.05
SWTH	0.10 ±0.04(4)	-	0.28	0.02
TESW	-	0.08	-	-
TEWA	0.20 ±0.14(4)	-	0.28	-
TTWO	0.04 ±0.05(4)	-	-	-
WTSP	0.04 ±0.05(4)	0.16	-	-
WWCR	-	-	-	0.06
YBFL	0.04 ±0.05(4)	-	-	-
YRWA	0.18 ±0.14(4)	-	-	0.02

* See Appendix 1 for bird species code and names.

At Norman Wells, 15 species were detected in 2004 compared to 17 species during historical surveys (Table 29). Comparisons for historical and current densities were possible for nine species at Norman Wells. Of these, the density of four species had decreased in 2004 from historical records; five species remained unchanged in density, while none increased in density. Of the five most common species in each period, three remained the same: Chipping Sparrow, Swainson's Thrush and Yellow-rumped Warbler. In the 1970s, Gray Jay and Tennessee Warbler were detected at higher densities, while Dark-eyed Junco and Palm Warbler were more common in 2004.

Table 29: Current and historical bird densities for black spruce-open habitat near Norman Wells, NT. The area of habitat surveyed in 2004 = 36.75 ha.

Species	2004 Average Individuals/Ha±SD (n)	1972 Average Individuals/Ha	1973 Average Individuals/Ha	1974 Average Individuals/Ha
		25.2 Ha sampled	*5.8 Ha sampled*	*86.2 Ha sampled*
AMRO	0.03 ±0.05(3)	0.04	0.17	-
BOWX	0.03 ±0.05(3)	-	0.17	-
BPLW	0.04 ±0.05(3)	0.20	0.34	-
CHSP	0.30 ±0.17(3)	-	0.17	0.64
DEJU	0.14 ±0.05(3)	-	-	0.29
GCTH	-	0.04	-	-
GRJA	0.08(3)	0.08	1.2	0.98
HETH	0.08(3)	-	-	-
LISP	0.11 ±0.12(3)	-	-	-
NOWA	-	-	0.17	-
OCWA	0.11 ±0.05(3)	-	-	-
PAWA	0.19 ±0.19(3)	0.04	-	-
PIGR	0.03 ±0.05(3)	-	-	-
PISI	-	-	-	0.10
RCKI	0.03 ±0.05(3)	-	-	-
RUBL	-	0.04	0.52	
SAVS	-	0.16	-	-
SWTH	0.14 ±0.17(3)	-	0.34	0.28
TESW	-	0.04	-	-
TEWA	-	-	-	0.28
WCSP	0.03 ±0.05(3)	-	-	-
WWCR	-	0.60	-	-
YRWA	0.14 ±0.05(3)	0.52	-	-

* See Appendix 2 for bird species code and names.

Deciduous

Community composition

Deciduous habitat types were sampled in both the Norman Wells and Fort Simpson study areas in the 1970s and 2004. At Fort Simpson, 19 species were detected in deciduous habitats during 2004 surveys, while 18 species were detected during historical surveys (Table 30). Seven of the 18 historical detections were consistently observed both in 1972 and 1975, and two of these species (Boreal Chickadee and Hermit Thrush) were not detected during the 2004 surveys. Seven species detected in 2004 were not detected during historical surveys.

Table 30: Current and historical bird community composition in deciduous habitat near Fort Simpson, NT.

Bird Species	2004	1972	1975	Bird Species	2004	1972	1975
AMRE	*	*	*	NOWA	*		
AMRO	*	*		OVEN	*	*	*
BAWW	*	*		PISI			
BOCH		*	*	REVI	*	*	*
CHSP			*	RUGR	*		
DEJU			*	SWTH	*	*	
DOWO	*			TEWA	*	*	*
FOSP	*			WAVI	*		
GRJA	*		*	WETA	*	*	
HETH		*	*	WTSP	*		
LEFL	*	*		YBSA	*		
MAGW	*		*	YRWA	*	*	*
NOGO			*	YWAR		*	
				Total # Species	19	13	12

* Species detected both "on" and/or "off" survey transects (1970s) or survey plots (2004); see Appendix 1 for bird species codes and names.

At Norman Wells, 14 species were detected during the 1970s, while 30 species were detected in 2004 in deciduous habitats (Table 31). Twenty-one of the 30 species detected in 2004 were not detected during historical surveys, which may be due in part to only six hectares of this habitat being sampled during historical surveys.

Table 31: Current and historical bird community composition in deciduous habitat near Norman Wells, NT.

Bird Species	2004	1972	1974	Bird Species	2004	1972	1974
ALFL	*			OCWA	*		
AMRE			*	OVEN			*
AMRO	*			PISI			*
BAWW	*		*	REVI			*
BHVI			*	RUBL	*		*
BOCH			*	RWBL	*		
CCSP	*			SAVS	*		
CHSP	*	*		STGR	*		
CORE	*			SWSP	*		
DEJU	*			SWTH	*	*	
FOSP	*			TESW	*		
GGOW	*			TEWA	*		*
HAWO	*			WAVI	*		
HETH	*			WCSP	*		
LEFL			*	WISN	*		
LISP	*			WTSP	*		
MAGW	*			WWPE	*		
NOWA	*			YRWA	*	*	*
				YWAR	*		*
				Total # Species	**30**	**3**	**12**

* Species detected both "on" and/or "off" survey transects (1970s) or survey plots (2004); see Appendix 2 for bird species codes and names.

Species densities

At Fort Simpson, 14 species were detected during 1970s surveys, while 17 species were detected in 2004 in deciduous habitats (Table 32). Six of these species overlapped survey periods, allowing for density comparisons. Of these, three species had lower densities in 2004, 2 species remained unchanged, and one species (Red-eyed Vireo) had increased in density from historical levels. Red-eyed Vireo was among the most common species in both survey periods, along with Least Flycatcher and Tennessee Warbler in 2004 and Pine Siskin, Yellow-rumped Warbler and Black-and-white Warbler in the 1970s.

At Norman Well, nine species were detected in 2004, while six species were detected during 1970s surveys in deciduous habitats (Table 33). Of the five species occurring during both study periods, four had lower densities in 2004 and one had an increased density. The most commonly detected species in the 1970s were Pine Siskin, Tennessee Warbler and Yellow-rumped Warbler, which were also among the most common species in 2004, along with Swainson's Thrush and Orange-crowned Warbler.

Table 32: Current and historical bird densities for deciduous habitat near Fort Simpson, NT. The area of habitat surveyed in 2004 = 12.25 ha.

Species	2004 Average Individuals/Ha±SD (n)	1972 Average Individuals/Ha	1974 Average Individuals/Ha	1975 Average Individuals/Ha
		3.5 Ha sampled	*4.8 Ha sampled*	*12.0 Ha sampled*
AMRE	0.08(1)	0.29	-	0.33
AMRO	0.08(1)	-	-	-
BAWW	0.16(1)	0.29	0.60	-
BOCH	-	-	-	0.17
CHSP	-	-	-	0.08
DEJU	-	-	-	0.21
DOWO	0.08(1)	-	-	-
FOSP	0.08(1)	-	-	-
GRJA	-	-	-	0.16
HETH	-	0.29	-	0.08
LEFL	1.55(1)	-	-	-
MAGW	0.08(1)	-	-	0.09
NOWA	0.08(1)	-	-	-
OVEN	0.65(1)	-	-	0.08
PISI	-	-	1.02	-
REVI	0.90(1)	0.57	-	0.33
RUGR	0.08(1)	-	-	-
SWTH	0.16(1)	-	-	-
TEWA	0.90(1)	0.29	0.42	3.23
WAVI	0.16(1)	-	-	-
WETA	0.08(1)	-	-	-
YBSA	0.90(1)	-	-	-
YRWA	0.16(1)	0.29	0.84	0.26
YWAR	-	0.57	-	-

* See Appendix 1 for a list of bird species codes and names.

Table 33: Current and historical bird densities for deciduous habitat near Norman Wells, NT. The area of habitat surveyed in 2004 = 12.25 ha.

Species	2004 Average Individuals/Ha±SD (n)	1972 Average Individuals/Ha	1974 Average Individuals/Ha
		1.2 Ha sampled	*4.8 Ha sampled*
BAWW	0.16(1)	-	0.6
CHSP	0.08(1)	0.83	-
DEJU	0.08(1)	-	-
MAGW	0.08(1)	-	-
OCWA	0.49(1)	-	-
PISI	-	-	1.02
SWTH	0.49(1)	0.83	-
TEWA	0.08(1)	-	0.42
WAVI	0.24(1)	-	-
YRWA	0.41(1)	0.83	0.84

* See Appendix 2 for a list of bird species codes and names.

Fire regenerating - low shrubland

Community Composition

Fire regenerating - low shrubland habitats were only surveyed in the Norman Wells area, with relevant historical surveys in 1972 and 1973. A total of 24 species were recorded in this habitat during historical surveys, while 33 species were detected in 2004 (Table 34). Of the 24 species detected in the 1970s, only three were detected consistently in both 1972 and 1973; one of these (American Robin) was absent from 2004 surveys. In 2004 surveys, 18 species were detected that were absent during historical surveys.

Species Densities

At Norman Wells, 20 species were detected during 2004 surveys, while 17 species were detected during historical surveys for fire regenerating - low shrubland habitats (Table 35). Seven species were detected in both survey periods. When densities of these species were compared, four species had lower densities in 2004, two retained similar densities, and one species (White-crowned Sparrow) had increased density in 2004. There was no overlap in the most common species detected during the two survey periods. Lincoln Sparrow, White-crowned Sparrow and Chipping Sparrow were the most common species detected in this habitat during 2004, while Bohemian Waxwing, Blackpoll Warbler and Yellow Warbler had the highest densities during historical surveys.

Table 34: Current and historical bird community composition in fire regenerating - low shrubland habitat near Norman Wells, NT.

Bird Species	2004	1972	1973	Bird Species	2004	1972	1973
ALFL	*	*		OVEN	*		
AMRO		*	*	PAWA	*	*	
ATSP		*		PIGR	*		
BAWW		*		RCKI	*		
BOWX	*		*	REVI	*		
BPLW	*	*		RUBL		*	
CCSP	*			SAVS	*	*	
CHSP	*		*	STGR	*		
CORE	*	*		SWSP	*		
DEJU	*			SWTH	*	*	
FOSP	*	*		TEWA		*	
GCTH		*		TRES	*	*	
GRJA	*	*	*	VATH	*		
HAWO	*			WCSP	*	*	*
HETH	*			WISN	*		
LEYE	*			WIWA		*	
LISP	*			WTSP	*	*	
MAGW	*			WWPE		*	
NOFL	*	*		YBSA	*		
NOWA	*			YRWA	*		
OCWA	*	*		YWAR		*	
				Total # Species	33	22	5

* Species detected both "on" and/or "off" survey transects (1970s) or survey plots (2004); see Appendix 2 for bird species codes and names.

Table 35: Current and historical bird densities for fire regenerating - low shrubland habitat near Norman Wells, NT. The area of habitat surveyed in 2004 = 61.25 ha.

Species	2004 Average Individuals/Ha±SD (n)	1972 Average Individuals/Ha	1973 Average Individuals/Ha
		13.7 Ha sampled	*4.7 Ha sampled*
ALFL	0.07 ±0.07(5)	0.22	-
AMRO	-	0.22	0.21
ATSP	-	0.22	-
BOWX	-	-	0.64
BPLW	0.03 ±0.07(5)	0.66	-
CCSP	0.11 ±0.16(5)	-	-
CHSP	0.20 ±0.16(5)	-	-
CORE	0.02 ±0.04(5)	0.22	-
DEJU	0.02 ±0.04(5)	-	-
FOSP	0.03 ±0.04(5)	0.07	-
GRJA	-	0.07	0.21
HAWO	0.02 ±0.04(5)	-	-
HETH	0.02 ±0.04(5)	-	-
LEYE	0.03 ±0.04(5)	-	-
LISP	0.42 ±0.27(5)	-	-
NOFL	-	0.07	-
NOWA	0.03 ±0.04(5)	-	-
OCWA	0.05 ±0.11(5)	0.07	-
PAWA	0.02 ±0.04(5)	-	-
RUBL	-	0.14	-
SAVS	0.03 ±0.18(5)	-	-
STGR	0.02 ±0.04(5)	-	-
SWSP	0.03 ±0.07(5)	-	-
TEWA	-	0.22	-
TRES	0.02 ±0.04(5)	0.14	-
WCSP	0.41 ±0.06(5)	0.07	-
WISN	0.02 ±0.04(5)	-	-
WIWA	-	0.07	-
WTSP	-	0.07	-
YWAR	-	0.44	-

* See Appendix 2 for a list of bird species codes and names.

White spruce

Community Composition

White spruce habitats were surveyed during the 1970s and 2004 at both the Fort Simpson and Norman Wells study areas. At Fort Simpson, 24 species were detected in 2004, while 16 species were recorded during 1972 and 1975 surveys (Table 36). In 2004, 16 of the 24 species detected had not been recorded during historical surveys. Gray Jay was consistently recorded during historical surveys, but was not detected during 2004 surveys. At Norman Wells, 19 species were detected during historical surveys, while 32 species were detected in 2004 (Table 37). Nineteen of the species detected in 2004 were not recorded during historical surveys.

Table 36: Current and historical bird community composition in white spruce habitat near Fort Simpson, NT.

Bird Species	2004	1972	1975	Bird Species	2004	1972	1975
AMRO	*			PISI			
BAWW	*			PIWO	*		
BBWA	*			PUFI	*		
BHVI	*	*		RCKI	*	*	
BOCH	*	*		REVI	*		
BPLW		*		RUBL			*
CHSP	*	*	*	SWTH	*	*	*
CMWA	*			TESW		*	
CORE				TEWA	*		*
DEJU	*	*		VATH	*		
GRJA		*	*	WAVI	*		
HAWO	*			WETA			*
MAGW	*			WTSP	*		
NOFL	*			WWCR		*	
OVEN	*			WWPE	*		
PAWA			*	YBSA	*		
PIGR		*		YRWA	*	*	
				Total # Species	**24**	**12**	**7**

* Species detected both "on" and/or "off" survey transects (1970s) or survey plots (2004); see Appendix 1 for bird species codes and names.

Table 37: Current and historical bird community composition in white spruce habitat near Norman Wells, NT.

Bird Species	2004	1972	1974	Bird Species	2004	1972	1974
ALFL		*		NOFL	*		
AMRO	*	*		OCWA	*		
BAWW	*			OSFL	*		
BBWO			*	PAWA	*		
BEKI		*		PIGR	*		
BHVI			*	PISI	*		
BOCH	*		*	RCKI	*	*	*
BOWA	*			RUGR	*		
BPLW	*	*		SPGR			*
CHSP	*	*		SWTH	*	*	*
CORE				TESW			*
COSN			*	TEWA	*	*	
DEJU	*			TTWO			*
FOSP	*			WAVI	*		
GRJA	*	*	*	WCSP	*		
HAWO	*			WETA	*		
HETH	*		*	WTSP	*	*	
LEFL			*	WWCR	*		
LEYE	*			WWPE	*		
LISP	*			YBSA	*		
MAGW	*			YRWA	*		
				Total # Species	**32**	**10**	**12**

* Species detected both "on" and/or "off" survey transects (1970s) or survey plots (2004); see Appendix 1 for bird species codes and names.

Species Densities

At Fort Simpson, 16 species were detected during historical surveys in 1972, 1974 and 1975, while 13 species were detected in 2004 in white spruce habitats (Table 38). Six of these species occurred in both periods and allowed for density comparisons. Densities for three of the species remained similar, two of the species had lower densities in 2004, and one species (Tennessee Warbler) had an increased density compared to historical levels. The most common species in both periods was Chipping Sparrow. In 2004, Tennessee Warbler and Yellow-breasted Sapsucker also had high densities, while White-winged Crossbill and Swainson's Thrush had among the highest densities during historical surveys.

At Norman Wells, 22 species were detected during 2004 surveys and six species during historical surveys in white spruce habitats (Table 39). Only one of the six species detected in the 1970s occurred in 2004 to allow for density comparisons; Chipping Sparrow had lower densities in 2004 compared to historical surveys. Twenty-one of the species detected in 2004 had not been recorded in historical surveys. Of the six species that were historically detected, five were not recorded in 2004, indicating that species composition differed between the two survey periods. The most common species during the 1970s were Pine Siskin, Common Redpoll and Chipping Sparrow, while in 2004, the highest densities were of Yellow-rumped Warbler, Tennessee Warbler, Swainson's Thrush and Dark-eyed Junco.

Table 38: Current and historical bird densities for white spruce habitat near Fort Simpson, NT. The area of habitat surveyed in 2004 = 12.25 ha.

Species	2004 Average Individuals/Ha±SD (n)	1972 Average Individuals/Ha	1974 Average Individuals/Ha	1975 Average Individuals/Ha
		9.8 Ha sampled	*20 Ha sampled*	*2.4 Ha sampled*
AMRO	0.08(1)	-	-	-
BBWA	0.08(1)	-	-	-
BHVI	-	0.10	-	-
BOCH	-	0.10	-	-
BPLW	-	0.10	-	-
CHSP	0.41(1)	-	0.48	0.82
CMWA	0.08(1)	-	-	-
CORE	-	-	0.42	-
DEJU	0.08(1)	0.10	-	-
GRJA	-	0.10	-	0.44
MAGW	0.08(1)	-	-	-
OVEN	0.16(1)	-	-	-
PAWA	-	-	-	0.44
PISI	-	-	0.48	-
RCKI	0.08(1)	0.20	-	-
RUBL	-	-	-	0.44
SWTH	0.16(1)	0.20	-	0.82
TESW	-	0.20	-	-
TEWA	0.73(1)	-	-	0.44
WETA	0.16(1)	-	-	0.44
WWCR	-	3.06	-	-
YBSA	0.41(1)	-	-	-
YRWA	0.24(1)	-	-	-

* See Appendix 1 for a list of bird species codes and names.

Table 39: Current and historical bird densities for white spruce habitat near Norman Wells, NT. The area of habitat surveyed in 2004 = 36.75 ha.

Species	**2004 Average Individuals/Ha±SD (n)**	**1972 Average Individuals/Ha**	**1974 Average Individuals/Ha**
		9.4 Ha sampled	*20.0 Ha sampled*
ALFL	-	0.11	-
AMRO	-	0.11	-
BAWW	0.03 ±0.05(3)	-	-
BOCH	0.03 ±0.05(3)	-	-
BOWA	0.03 ±0.05(3)	-	-
BPLW	0.14 ±0.12(3)	-	-
CHSP	0.19 ±0.09(3)	-	0.48
CORE	-	-	0.42
DEJU	0.22 ±0.12(3)	-	-
FOSP	0.03 ±0.05(3)	-	-
GRJA	0.05 ±0.05(3)	-	-
HETH	0.08 ±0.08(3)	-	-
LISP	0.03 ±0.05(3)	-	-
MAGW	0.14 ±0.24(3)	-	-
OCWA	0.16 ±0.08(3)	-	-
PAWA	0.11 ±0.12(3)	-	-
PIGR	0.03 ±0.05(3)	-	-
PISI	-	-	0.48
RCKI	0.08 ±0.08(3)	-	-
SWTH	0.30 ±0.17(3)	-	-
TEWA	0.22 ±0.24(3)	-	-
WAVI	0.03 ±0.05(3)	-	-
WCSP	0.03 ±0.05(3)	-	-
WETA	0.03 ±0.05(3)	-	-
WTSP	-	0.11	-
YBSA	0.03 ±0.05(3)	-	-
YRWA	0.22 ±0.12(3)	-	-

* See Appendix 2 for a list of bird species codes and names.

Jack pine

Community Composition

Jack pine habitat was only sampled at the Fort Simpson study area. During both 2004 and historical surveys, 13 species were detected in this habitat (Table 40). The species composition, however, differed between the two survey periods. Seven of the species recorded in 2004 were not detected historically, and seven species from 1974 and 1975 surveys were absent during 2004 surveys.

Table 40: Current and historical bird community composition in jack pine habitat near Fort Simpson, NT.

Bird Species	2004	1974	1975	Bird Species	2004	1974	1975
AMRE			*	HETH	*		
AMRO	*			LEFL			*
BAWW	*			MAGW	*		
BBWA			*	OVEN	*		
BBWO	*			PISI		*	
BHVI	*			RCKI		*	*
CHSP	*	*	*	SWTH	*	*	*
CMWA			*	TEWA	*	*	*
DEJU	*		*	WETA			*
GRJA	*	*	*	YRWA	*		*
				Total # Species	**13**	**6**	**12**

* Species detected both "on" and/or "off" survey transects (1970s) or survey plots (2004); see Appendix 1 for bird species codes and names.

Species Densities

During 2004 surveys, eight species were detected, while during 1970s surveys, 13 species were detected in jack pine habitats (Table 41). Four of these species were recorded in both periods. While none of these species had increased densities in 2004, 3 species showed a decline in density and one species retained approximately the same density. Chipping Sparrow and Tennessee Warbler remained at high densities in both periods, while Ovenbird had higher densities in 2004 and Gray Jay had higher densities during historical surveys.

Table 41: Current and historical bird densities for jack pine habitat near Fort Simpson, NT. The area of habitat surveyed in 2004 = 12.25 ha.

Species	2004 Average Individuals/Ha±SD (n)	1974 Average Individuals/Ha	1975 Average Individuals/Ha
		8.5 Ha Sampled	*8.7 Ha Sampled*
AMRE	-	-	0.49
BAWW	0.08(1)	-	-
BBWA	-	-	0.11
BHVI	0.08(1)	-	-
CHSP	0.16(1)	0.72	0.22
CMWA	-	-	0.22
DEJU	-	0.36	0.38
GRJA	-	2.09	1.3
HETH	0.08(1)	-	-
LEFL	-	-	0.11
OVEN	0.41(1)	-	-
PISI	-	0.60	-
RCKI	-	0.60	0.22
SWTH	0.16(1)	0.60	0.60
TEWA	0.33(1)	0.60	1.26
WETA	-	-	0.11
YRWA	0.16(1)	-	0.22

* See Appendix 1 for a list of bird species codes and names.

Low shrubland

Community Composition

Low shrubland habitat was only sampled in the Fort Simpson area. Historical surveys in 1972 and 1975 recorded 26 species in this habitat type, while 22 species were detected during 2004 surveys (Table 42). Of the species detected in the 1970s, seven species were consistently detected in both years. Four of these species were not recorded in 2004, including American Robin, Dark-eyed Junco, Palm Warbler and Rusty Blackbird. However, there were eight additional species detected in 2004 that were not recorded during historical surveys.

Table 42: Current and historical bird community composition in low shrubland habitat near Fort Simpson, NT.

Bird Species	2004	1972	1975	Bird Species	2004	1972	1975
ALFL	*		*	PAWA		*	*
AMRE		*	*	PISI			*
AMRO	*		*	RCKI	*		
BAWW			*	RUBL		*	*
BPLW		*		RWBL	*	*	
CCSP	*	*		SACR	*		
CHSP	*		*	SORA	*		
COYE	*	*		SOSA	*	*	
DEJU		*	*	SWSP	*	*	
GRJA		*		SWTH			*
LCSP	*	*		TESW		*	
LEFL		*		TEWA	*	*	*
LISP	*	*	*	WIWA	*		
NOFL	*			WTSP	*	*	
NOWA	*	*	*	WWPE	*		
NSTS	*			YRWA	*		*
OSFL	*			YWAR		*	
				Total # Species	**22**	**19**	**14**

* Species detected both "on" and/or "off" survey transects (1970s) or survey plots (2004); see Appendix 1 for bird species codes and names.

Species Densities

During 2004 surveys, 10 species were detected, while 18 species were detected during 1972 and 1975 surveys in jack pine habitat (Table 43). Seven of these species occurred during both periods, which allowed for density comparisons. Densities in 2004 were higher for one species (Lincoln Sparrow) and lower for six species. Swamp Sparrow commonly occurred during both historical and 2004 surveys, while Clay-colored Sparrow and Lincoln Sparrow had high densities in 2004. During historical surveys, Blackpoll Warbler, Dark-eyed Junco and Rusty Blackbird had high densities.

Table 43: Current and historical bird densities for low shrubland habitat near Fort Simpson, NT. The area of habitat surveyed in 2004 = 12.25 ha.

Species	2004 Average Individuals/Ha±SD (n)	1972 Average Individuals/Ha	1975 Average Individuals/Ha
		6.7 Ha sampled	*5.8 Ha sampled*
ALFL	0.08(1)	-	0.31
AMRE	-	0.45	0.15
AMRO	0.08(1)	-	0.19
BAWW	-	-	0.14
BPLW	-	0.75	-
CCSP	0.49(1)	-	-
CHSP	0.08(1)	0.30	0.35
COYE	0.49(1)	-	-
DEJU	-	-	0.52
GRJA	-	0.45	-
LCSP	0.16(1)	-	-
LISP	0.33(1)	0.15	0.17
NOWA	-	0.45	0.17
PAWA	-	0.30	0.17
PISI	-	-	0.15
RUBL	-	-	0.52
SWSP	0.65(1)	1.04	-
SWTH	-	-	0.17
TEWA	0.08(1)	0.15	0.46
WTSP	0.08(1)	0.30	-
YRWA	-	-	0.15

* See Appendix 1 for a list of bird species codes and names.

NWT Bird Checklist Data

Two hundred sixty-nine bird species, including 109 songbird species, were recorded in NWT Bird Checklist database for the Mackenzie Valley (Appendix 14). Spot mapping surveys at Fort Simpson and Norman Wells detected 75 (28.0%) of these species, including 53 (48.6%) of the songbird species recorded on the database. The majority of the bird species from the database that were not detected by the 2004 spot mapping surveys were waterfowl (loons, grebes, ducks, geese), shorebirds, gulls, and raptors.

DISCUSSION

Densities of Birds in 2004: Spot Mapping

Bird densities varied greatly between study areas and between habitat types. Densities at Fort Simpson were higher than densities at Norman Wells. Individual species varied markedly in densities with some species being relatively abundant in one or more habitats and of low abundance or absent from others. For example Least Flycatcher, had the highest density of any bird species in any one habitat (1.57 territories/ha in deciduous forest at Fort Simpson; Appendix 4), but were entirely absent from other habitats).

Densities are likely more or less normal for most of the common species. Inter-year variation in abundances and densities in songbirds that have large ranges is often linked to food availability, which could be problematic for studies based on one year of data. For example, species such as the Tennessee Warbler (one of the most abundant birds in the two study areas in 2004), and the Bay-breasted and Cape May Warblers (two of the least abundant birds) are known to respond to spruce budworm outbreaks. Yet the Tennessee Warbler is consistently one of the most abundant birds detected on BBS, and the latter two are rarely, if at all, detected. This suggests that densities in 2004 reflect *normal* conditions. We expect this to hold more or less true for most other species, although nomadic species such as Pine Siskin and White-winged crossbill are notoriously variable from year to year and season to season.

Densities from the two study areas should not be extrapolated, except with great caution, beyond the boundaries of the pipeline segments analyzed in this study. However, there are many similarities between species abundances and habitat affinities in this study and with studies conducted further south in the Liard River valley. In that region, species such as Tennessee Warbler, Magnolia Warbler, Swainson's Thrush, Yellow-rumped Warbler, Chipping Sparrow, Gray Jay, Yellow-bellied Sapsucker, and Ovenbird were relatively common (Machtans and Latour 2003), as they were at Norman Wells and Fort Simpson. However, some species that were relatively common in the Liard River valley (Bay-breasted Warbler, Red-breasted Nuthatch, Cape May Warbler) were relatively uncommon at Norman wells and Fort Simpson; and species relatively common in our study areas (Alder Flycatcher, Palm Warbler, Warbling Vireo) were relatively uncommon in the Liard River valley. Some of these differences can likely be explained by different survey emphasis on certain habitats between the areas.

Spot map plots at Norman Wells and Fort Simpson were designed to cover the major habitat types present in the study areas, approximately at proportions that each habitat represents across the landscape. While interesting unto itself, the real utility of the density data was to allow calculations of estimated bird losses at the species level. Estimates of losses are fully discussed in Chapter 3.

Habitat and breeding bird community relationships

DCA analyses showed that, in general, common bird species were most often associated with habitats expected given existing knowledge of habitat use in boreal regions (e.g., Machtans and Latour 2003). For example, in this study, Swainson's Thrush was strongly associated with mixed spruce forest at Norman Wells, but was present in most forested habitats at both study areas. In the Liard River valley of NWT, the Swainson's Thrush was relatively ubiquitous being equally common in coniferous and deciduous forests, less common in mixedwoods, and wooded bogs, and absent from stands regenerating following clearcutting (Machtans and Latour 2003). A second example is that Least Flycatchers were only associated with deciduous forest. This habitat association was expected, however, as in the NWT, Least Flycatchers are known to occur in young or deciduous forest but not in coniferous forests (Machtans and Latour 2003), and in the Yukon, it is a riparian specialist that occurs in balsam poplar stands in river floodplains or valleys (Sinclair et al. 2003).

Some differences were noted however. For example, in this study Dark-eyed Junco was found to be associated with black spruce communities in both study areas, whereas, in the Liard River valley, juncos only bred in stands regenerating after recent clearcutting or wooded bogs, and avoided forested habitats (Machtans and Latour 2003). This discrepancy could be explained if the more northern areas studied here had more open forest structure (favoured by juncos).

Most species were found in more than one habitat but a few were confined to only one habitat type: open black spruce forest-American Robin, Spruce Grouse, Three-toed Woodpecker and Yellow-bellied Flycatcher; jackpine-Blue-headed Vireo; deciduous forest-Least Flycatcher, Red-eyed Vireo, American Redstart, Downy Woodpecker, Fox Sparrow, Ruffed Grouse; white spruce forest-Bay-breasted Warbler, Western Tanager, Yellow-bellied Sapsucker; low shrubland-Common Yellowthroat, LeConte's Sparrow; and fire regen-low shrubland-Savannah Sparrow, alder Flycatcher, Common Redpoll, Sharp-tailed Grouse, Wilson's Snipe (Appendix 4 and 5).

Breeding Bird Surveys

Breeding Bird Surveys were analyzed mainly to get a sense of how well the spot map surveys captured the breeding bird communities and whether or not 2004 was a "typical" year for bird abundances in the study areas. Unto itself, the BBS revealed abundant and diverse songbird communities in the Mackenzie Valley. The densities of songbird species and the composition of the songbird community showed similarities as well as differences across the Mackenzie Valley landscape. A majority of songbird species were commonly detected on at least two of the three routes and many had a significantly greater abundance at one or more of the routes. The overall abundance detected on each of the routes was relatively constant with only slight increases apparent on the Fort Simpson and Norman Wells routes. Overall abundances differed between routes though, with Norman Wells consistently recorded lower numbers than Fort Liard and Fort

Simpson routes. This agrees with the overall observed lower densities of birds on the spot mapping plots in Norman Wells compared to the ones farther south near Fort Simpson. This result is also one that would be expected given that many forest-breeding birds are reaching or surpassing their ranges near Norman Wells (NWT/NU Bird Checklist Database).

Uncommon species and those species recorded on only one route represented about 25% of the Mackenzie Valley songbird community. Most often these rare species were found at Fort Liard, the southern-most location, suggesting detection of some species likely at the northern limit of their geographical range. An additional 30% of common species, absent from detection at Norman Wells, the northern-most route, are likely also near their northern geographic limit within the Mackenzie Valley.

A comparison of common songbird species abundance showed differences in relative abundance as well as yearly mean abundance over time and between routes. Predominance by a few species is evident on all routes. The majority of common bird species appear to have moderate yearly mean abundance that differs over time. Few species demonstrate a similar abundance over time and between routes. Among the 10 most common species, four species appear to be increasing, four species appear to be decreasing and two demonstrate both increasing and decreasing trends at different locations. Overall, the observed differences in individual species abundance over time suggest the occurrence of stochastic events in the songbird community.

Comparison of 2004 spot mapping surveys with Breeding Bird Surveys

Of the 20 most abundant bird species detected on BBS at Norman Wells and Fort Simpson (species >10 birds/survey; Table 21), all were detected during 2004 spot map surveys. In general the most abundant birds on BBS were among the most abundant birds detected during spot map surveys, but there were major differences for some species. For example, at Norman Wells, Chipping Sparrow (1st most abundant on BBS), Yellow-rumped Warbler (2nd) and Lincoln's Sparrow (4th), Dark-eyed Junco (6th) and Orange-crowned Warbler (7th) were detected at relatively high densities on spot map plots. On the other hand, American Robin (3rd) and Alder Flycatcher (5th) were detected at relatively low densities. At Fort Simpson, Tennessee Warbler (1st most abundant on BBS; Table 21), Yellow-rumped Warbler (3rd), Chipping Sparrow (4th), Red-eyed Vireo (6th), and Ovenbird (10th) were detected at relatively high densities on spot map plots. Swainson's Thrush (2nd), White-winged Crossbill (5th), Magnolia Warbler (7th), Alder Flycatcher (8th), and White-throated Sparrow (9th) were detected at relatively low densities.

This brief analysis shows the utility of spot map surveys for determining actual and relative densities across the landscape. Because BBS occur along roads, birds associated with edges and birds that can be heard for long distances are detected more often than would be expected compared to birds that occupy interior forest habitat, or avoid edge, or whose songs do not carry as far to the human ear. Many species which are detected on

BBS at high rates but are detected at much lower rates on spot map plots (e.g., Alder Flycatcher, American Robin, Magnolia Warbler, White-throated Sparrow) favour forest edge habitats and are more likely to occur along roads than in more continuous habitat. Other species tend to be over represented on BBS compared to actual breeding densities because their song carries for long distances (Swainson's Thrush) or are nomadic and tend to be detected as fly bys (White-winged Crossbill).

Several species that occur at relatively high densities on some spot map plots were under represented on BBS (e.g., Yellow-bellied Sapsucker, Clay-colored Sparrow, Common Yellowthroat, Palm Warbler, White-crowned Sparrow, Bohemian Waxwing). The most probable explanation for this is that BBS routes do not pass through some habitats so some species are detected less often than they occur on the landscape.

A few passerine species that were detected at low to moderate rates on BBS (e.g., American Crow, Canada Warbler, Common Raven, Eastern Kingbird, Eastern Phoebe, Olive-sided Flycatcher, Rose-breasted Grosbeak, Red-breasted Nuthatch, Red-winged Blackbird, Song Sparrow, Varied Thrush, Western Wood-Pewee, and Yellow Warbler) were not recorded as having even one territory on spot map plots. These species either occur at low densities or occur irregularly from year to year. These species were then not included in calculations of habitat and breeding pairs lost to the pipeline; therefore, are under obviously represented in those calculations. Two songbird species not detected on BBS (Bay-breasted Warbler, Pine Grosbeak) were recorded on spot map plots.

In conclusion, a comparison of BBS data (1989-2003) and spot map data (2004) do not indicate that 2004 was an abnormal year in terms of species diversity or relative abundance. It does indicate that some species were missed by the spot map surveys (as would be expected by a small, focused study) and those species will not be represented in calculations of habitat and breeding pairs predicted to be lost.

Historical data

Preliminary comparisons for bird community composition and species densities were made between historical 1972-1975 bird surveys and 2004 surveys near Fort Simpson and Norman Wells. Although these comparisons provide some useful indications of changes in species diversity and bird densities, these comparisons should be considered preliminary and interpreted cautiously for several reasons.

Survey protocols were different between survey periods. Most of the historical surveys were conducted between 0800-1500 hrs, due to the logistical difficulties of accessing sites during the 1970s. Surveys in 2004 typically began at sunrise and consequently included data from the peak songbird dawn chorus. This would be of particular importance in dense habitats, where detections are more likely to be auditory than visual. Historical surveys consisted of transect surveys where two observers walked parallel transect lines approximately 18 m apart and noted all birds detected between them. In 2004, spot mapping surveys were used where a single observer recorded all bird detections while walking parallel transects within an establish grid. Each survey protocol has different biases for detecting bird species. Collectively, these discrepancies in survey protocols between historical and 2004 surveys may be a factor affecting the changes in community composition and densities that were observed.

Surveys were conducted at different sites between survey periods. Sites surveyed in the 1970s were not revisited and resurveyed in 2004. As a result, it is difficult to determine which changes in bird population and density trends are real and which are attributable to the inherent biases associated with comparing habitats sampled at different sites. Although sites that were compared may have appeared to be ostensibly the same habitats, the sites may have had ecotones and microclimates that were present which dramatically influenced bird communities, and as a result, skewed data and biased comparisons.

Habitat categories that were compared between survey periods were, in some cases, different from one another. For example, the low shrubland habitat category from 2004 surveys, had 7 different habitat category counterparts from 1970s surveys that were used in the comparative analysis (Table 10). Furthermore, white spruce habitats surveyed at Norman Wells had only one bird species that was detected during both historic and 2004 surveys (Table 39). If these sampling plots consisted of the same habitat type, then it is more than likely that there would be more than one species in common between survey periods. It is unclear whether these lumped habitat types between survey periods provide for accurate comparisons. Regardless, these comparisons should be viewed as rudimentary in nature and preliminary in scope and were developed from the only baseline data that were currently available.

In considering changes in avian community structure between the 1970s and 2004 surveys, several key differences became apparent. Although the number of species detected in different habitats was often similar between historical and current surveys, the species composition appeared to have changed since the 1970s. The density of species present in both survey periods had often either declined or remained the same in the 2004 surveys compared to the 1970s surveys. Only in few cases were increases in density noted in 2004.

In each of the habitats, the overall trend in community composition changes suggested an increase in species diversity in 2004 compared to the surveys in the 1970s. In total, 57 species that had not been detected during historical surveys within each particular habitat type were recorded in 2004. Species that were absent historically, but were recorded in at least three different habitat types in 2004, were Lincoln Sparrow, Magnolia Warbler and Orange-crowned Warbler at Norman Wells, and American Robin, Black-and-white Warbler, Magnolia Warbler, Northern Flicker, White-throated Sparrow and Yellow-bellied Sapsucker at Fort Simpson.

Five species were recorded regularly at Fort Simpson in 2004, but not at Norman Wells: American Robin, Sora, Cape May Warbler, Ovenbird and Blue-headed Vireo. Although the American Robin is well within its range around Norman Wells, the area is at the northern edge of the range of the Sora. Norman Wells is past the accepted range of Cape May Warblers, Ovenbirds and Blue-headed Vireos, and it is therefore not surprising these were not detected at this more northern locale. Recent changes in climate, including warmer and longer summers (Natural Resources Canada 2004b), may also account for some of the noted changes in bird communities between survey periods.

Although all of the habitat types in each of the study areas experienced an increase in species diversity in 2004 compared to historical surveys, deciduous habitat around Norman Wells and white spruce habitat at Fort Simpson had the greatest apparent increase of species diversity. Conversely, black spruce-open habitats near Norman Wells and deciduous habitats near Fort Simpson had the smallest increases in species diversity from historical levels. These differences in the amount of change in species diversity in different habitat may be a sampling artefact, as the habitats with a large increase in diversity overall were sampled slightly less in the 1970s than the habitats where the increase in diversity was less pronounced.

Bird densities were generally similar or lower in 2004 compared to historical levels among most species, habitat types and study sites measured. Of 56 different comparisons of densities made between 2004 and 1970s surveys, 31 (55%) of species saw a notable decline in density, while 19 (34%) had similar densities to the historical surveys. There were six species that increased in density, which were spread over six different study site and habitat combinations. The species which appeared to have increased in density were Yellow-rumped Warbler in black spruce-open habitats at Fort Simpson; Black-and-white Warbler and Red-eyed Vireo in deciduous habitats at both Norman Wells and Fort Simpson; White-crowned Sparrow in fire regenerating - low shrubland habitat at Norman Wells; Tennessee Warbler in white spruce habitat at Fort Simpson; and Lincoln Sparrow in low shrubland habitat at Fort Simpson. When the different sites and habitats were compared, it appeared that Norman Wells habitats had greater instances of species densities declines than those of Fort Simpson habitats. The declines in densities in 2004 compared to historical levels were consistent for all the habitats examined.

One species, the Rusty Blackbird is thought to have declined precipitously throughout its range in North America (Greenberg and Droege 1999; Blancher 2003). Our analyses provide support for this decline as Rusty Blackbirds were not detected on spot map surveys in 2004 in habitats (open black spruce forest, white spruce forest, fire regenerating shrubland and low shrubland) where they had been detected in the 1970s.

NWT Bird Checklist Data

Many of the 207 bird species (Table 9) that are present in the Mackenzie Valley were not detected during 2004 spot map surveys. The implications of this result are that they were not captured in the analysis of potential losses of habitat and breeding birds. However, many of those species (43) are either accidental or casual in occurrence and are not expected to breed.

No attempt was made to estimate possible losses for species not detected during spot map surveys, nor for possible effects on migratory habitat. It is possible that some of these species will suffer some degree of negative impacts if the pipeline route passes through important habitat. However, potential impacts would likely be small for almost all these species at the population scale. Some individual pairs of nesting raptors (Peregrine Falcon, Gyrfalcon, Rough-legged Hawk, Golden Eagle), rare shorebirds (Upland Sandpiper) or woodpeckers (Pileated Woodpecker, Hairy Woodpecker) may be affected.

CONCLUSIONS

Densities of Birds in 2004: Spot Mapping

Density data from spot mapping in 2004 provides one of the critical components for estimates of losses from pipeline construction. Density data from 2004 is judged to reflect more or less *normal* abundance levels for the most common species of birds detected. Additional analyses of the data could reveal many interesting results about habitat use by many birds, especially songbirds, in the Mackenzie Valley.

Breeding Bird Surveys

BBS provide useful data for comparison with spot map surveys and provide a better overall snapshot of birds present in an area because BBS tend to cover more area and more habitats. Because BBS routes have been run for many years in both study areas, they can be used to assess the "typical" abundance of species in any given year and therefore show if 2004 was an atypical year for birds in the study area. Caveats for use in comparison with spot map surveys are that BBS do not provide density information, over represent edge species (especially those birds that frequent shrubby interfaces between forests and road clearings, over represent species with loud calls (e.g., Swainson's Thrush), and under represent forest interior birds and birds with less audible songs.

Historical Data

Overall, in examining apparent trends between survey periods, there is indication of subtle changes in bird species composition and densities from historical surveys. In general, species diversity has increased, while species densities have decreased over time. There are several possible explanations for these changes: differences in survey protocols, biases in habitat categories, changes in breeding distribution among species, climatic or environmental changes, and the like. None of which appears to be a dominant factor. It is unknown if these perceived changes are part of a longer-term trend or simply an annual fluctuations. Datasets that were compared for this study were snapshots in time, one from a few years in the early 1970s, the other, a single year in the new millennium. All results should be considered preliminary. Further studies, which more rigorously sample throughout the pipeline corridor, in several years, would be required to provide the most meaningful analysis and accurate comparisons.

NWT Checklist Data

Checklist data provide an overall list of birds that occur in the Mackenzie Valley. A brief analysis of records (numbers of records, numbers of birds, locations) allowed the estimation of a generalized status of each species. These data are useful for this report only for background reference when discussing details on individual species that are provided by the other data sets.

CHAPTER 3 – IMPACTS ON BIRDS

CALCULATED HABITAT LOSS ALONG THE MACKENZIE VALLEY GAS PIPELINE

More than 2,000 ha of habitat are estimated to be altered by pipeline clearings along a 200 km segment within each of the two study areas (Table 44). Differences in total areas between the two study areas, which would be expected to be the same, is explained by error associated with digitizing 400 km of pipeline route from 1:250,000 routing maps. The difference of about 130 ha is within error expected for this type of analysis.

Most of the habitat that will be greatly altered is forest (1,499 ha; 72.5%) or shrublands (292 ha; 14.1%), which will be cleared and converted to earlier seral stages. Sphagnum moss (50 ha; 2.4%), wetlands (27 ha; 1.3%) and herbaceous (11.2 ha; 0.5%) habitats will be severely disturbed during construction but habitat will retain or regain through succession, existing open structural features.

Table 44. Norman Wells approximated pipeline habitat loss in hectares by habitat category.

Habitat Category	**Ha**		
	Norman Wells	Fort Simpson	Total
Black spruce closed	359.24	304.49	663.73
Black spruce open	219.10	278.98	498.08
Mixed forest	156.44	17.11	173.55
fire regen/low shrubland open	83.47	0.31	83.78
White spruce	77.74	63.16	140.9
low shrubland	60.90	89.40	150.3
spruce-lichen boreal forest	51.45	38.03	89.48
sphagnum moss	44.38	5.15	49.53
wetlands	22.42	4.91	27.33
deciduous	17.03	29.47	46.5
tall shrubland - immature decid	13.48	44.27	57.75
Lichen dominant	10.52	6.16	16.68
herbaceous	0.09	11.11	11.2
jackpine	0	60.73	60.73
Total	1116.26	953.28	2069.54
			0
Clouds	16.52	0	16.52
non-vegetated	9.92	1.08	11
cloud or rock shadow	9.23	0	9.23
no data	2.52	0	2.52
Water	1.80	3.06	4.86
Grand Total	1156.25	957.42	2113.67

DISCUSSION OF IMPACTS TO BIRD HABITAT

Pipelines that pass through forests must be cleared of trees. Direct habitat loss is the only certain event that will occur in the Mackenzie Valley as a result of pipeline development. Construction of these types of linear development permanently alters wildlife habitat values because forest vegetation is replaced with shrub or grass dominated plant communities. Almost all pipeline impacts to vegetation itself are negative since they represent a complete removal or modification of the original vegetation pattern, and therefore a change in the local ecosystem dynamics (Tera Environmental Consultants 1982, 1983; De Santo and Smith 1993). Alterations to microclimatic, ground cover, and soil structural differences due to the compaction of soils by large machines affect both plant and animal species (Goosem and Marsh 1997; Ercelawn 1999; Grialou et al. 2000; Trombulak and Frissell 2000).

In the Mackenzie Valley, about 20 km^2 of habitat will be altered along the 1,300 km pipeline route (431 ha in the transition forest zone, 2209 ha in the northern taiga plains zone, and 2650 ha in the southern taiga plains zone [tables 9-25, 26, 27 in Volume 5D of Environmental Impact Statement for the Mackenzie Gas Project, 2004]). Although vegetation will be impacted severely, negative habitat effects for most wildlife species, especially birds, would be minimal unless a substantial portion or critical element of the habitat was rendered unsuitable by the development.

Creation and maintenance of young seral habitats

Pipeline construction and operation not only require the clearing of forested areas, but also the maintenance of early seral stages on the right-of-way. Although such habitats may provide good foraging habitat for many species, especially ungulates (Unsworth et al. 1998, O'Neil and Witmer 1991, Lowell and Crain 1999), the creation of early seral stages may destroy rare and endangered flora, introduce weeds and/or prevent the regeneration of suitable vegetation (Tera Environmental Consultants 1982, 1983, Calibre Consultants Inc. and Saskatchewan Energy Conservation and Development Authority 1994, Kirchhoff and Thomson 1998). Creation of young seral stages is expected to benefit a few open habitat bird species, and be negative for forest bird species. For instance, in studies of bird use of pipeline right-of-ways in Fort Liard, NWT, almost no species used the ROW in the first 5 years after creation. Those that did use the ROW appear to be using it for only a part of their territorial requirements, with the exception of a few species that favour wet, open habitats. (Hornbeck and Soprovich 2004).

Adjacent systems

Whether through simple habitat conversion or through the creation of new habitat, pipeline rights-of-way may modify adjacent ecosystems in many ways resulting in both increases or decreases to some wildlife populations, e.g., carnivores and ungulates (Crete et al. 1995; James and Stuart-Smith 2000). Exceptions include creating open habitats in forest which may attract species that use open habitats (e.g., Sharp-tailed Grouse, Savannah Sparrows).

Edge effect

When forested areas must be cleared in long narrow corridors there is a substantial creation of an edge. Edge effect is an important concept in wildlife ecology and is generally believed to be beneficial overall to wildlife by increasing patchiness and diversity of a community. Interior forest-dwelling wildlife lose habitat to the right-of-way, while habitat generalists, and mixed habitat or early successional species may increase in number (Kroodsma 1982; Loft and Menke 1984; Sopuck and Vernamn 1985; De Santo and Smith 1993; Knight et al. 1995; Jalkotzy et al. 1997; Morneau et al. 1999; Whitaker and Montevecchi 1999). However, impacts of cleared corridors on interior forest-dwelling birds is usually found to be negative, but is usually only detected in landscapes with substantial clearing of forest cover such as agricultural areas or highly impacted areas of forest (Chalfoun et al. 2002; Driscoll and Donovan 2004).

Nest predation and low reproductive rates are often associated with fragmented forests because predators forage along travel lanes such as edges (Paton 1994; Robinson et al. 1995; Whitaker and Montevecchi 1997). Increased levels of brood parasitism by Brown-headed Cowbirds are also often associated with fragmented landscapes (Robinson et al. 1995), although few cowbirds occur in the NWT and there is little evidence they are expanding in any rapid way (C. Machtans, pers comm.).

Biological, manual and chemical maintenance

Vegetation management programs are often implemented in order to control tall, woody vegetation that may interfere with pipeline maintenance. Three different control methods are usually used for vegetation maintenance: biological, manual and chemical. The use of machines for clearing is unselective and usually disruptive to the ecological development of desirable plant species. Hand cutting of the problem species has often been used in combination with chemical herbicides. Chemical maintenance, although successful, can cause unreasonable adverse effects on desirable ground-covering plant species and the environment if the application is not carefully controlled. Vegetation management on the Mackenzie Valley pipeline is unlikely to be short term problem in the NWT due to short growing seasons.

Any vegetation management protocols should consider the potential for contravening the Migratory Birds Convention Act with incidental take of birds, eggs, or nestlings during the bird breeding season.

Loss of old and mature forest

Clearing the right-of-way may result in removing food and shelter necessary for winter range usefulness and may reduce the wildlife diversity of the habitat for decades. Generally, however, removal of narrow bands of old or mature forest should have minor impacts on bird communities overall (Ercelawn 1999). However, losses must be assessed relative to the availability of various forest types and ages within the project area. In cases where the forest associations or age classes removed are very rare on the landbase, impacts may be locally great. Over the length of the Mackenzie Valley, the amount of old forest to be removed appears to be proportional to the removal of other vegetation types (Volume 5D of Environmental Impact Statement for the Mackenzie Gas Project, 2004]).

Water resources

Impacts of pipeline construction on water resources are primarily in the form of sediment added to streams. Fine sediment, which is held in suspension in the water, has the most serious impact because it can enter the water directly as a result of construction, vehicles, or bank erosion resulting from removal of the natural stabilizing stream bank vegetation. High concentrations of suspended sediment may kill aquatic organisms and impair aquatic productivity, but the impacts to forest birds would be expected to be negligible. (Ercelawn 1999; Trombulak and Frissell 2000).

Public access and disturbance

Roads required to service pipelines may create new access in remote areas. Responses to human disturbance are species-specific but public access can lead to additional mortality due to hunting, trapping, poaching, recreation, firewood cutting, noise, dust and management actions (Tera Environmental Consultants 1983; Tessman 1985; O'Neil and Witmer 1991; Unsworth et al. 1993, 1998; Thurber et al. 1994; Jalkotzy et al. 1997; Unsworth et al. 1998; Findlay and Bourdages 2000; Trombulak and Frissell 2000). Human disturbance of birds, particularly raptors nesting on support structures and birds using the corridor for resting, roosting, and hunting has also been documented along pipeline corridors (Jalkotzy et al. 1997). Public access is one of the greatest concerns associated with new developments in remote areas but can usually be mitigated with appropriate access controls.

Introduction of noxious weeds

Creation of pipeline corridors and use of heavy equipment greatly increases the likelihood of exotic species spreading and increasing their dominance by out-competing the native vegetation removed during construction. Exotic species are almost completely restricted to roadsides, streams and recent clear-cut (Ercelawn 1999, Trombulak and Frissell 2000). Invasive weeds can eliminate rare plant communities and out-compete desirable species reducing natural diversity and degrading bird habitat quality. The effects, although localized, can be great depending on the susceptibility of the impacted plant communities and the rate of spread of the weeds. Such effects are expected to be minimized in the NWT, however, as climate will likely limit spread of most invasive species.

Environmental contamination

Spills of petroleum products into terrestrial and particular aquatic ecosystems as a result of pipeline breaks and accidental discharges can have locally severe, and sometimes wide-ranging consequences for wildlife populations. An important route for petrochemical exposure for waterfowl is ingestion of contaminated grits and sediments (King and Bendell-Young 2000). Environmental management programs should provide for adequate protection of sensitive areas.

NUMBERS OF BIRDS THAT WOULD BE DISPLACED ALONG THE MACKENZIE VALLEY PIPELINE

Data from Norman Wells and Fort Simpson suggest that, for species surveyed using spot mapping in 2004, an estimated 1812 breeding pairs (689 at Norman Wells and 1123 at Fort Simpson) of 49 species of landbirds will be lost due to pipeline construction along 400 km of the pipeline (200 km sections in each of Norman Wells and Fort Simpson) (Table 45 and 46). Total habitat lost is expressed as a cumulative total; because more than one species occurs in each habitat type the total is greater than the actual amount (2069 ha) of habitat impacted. Details of estimated losses by habitat type for each bird species is presented in Appendix 4 and 5. Many other bird species that were not surveyed by the spot mapping study in 2004 will also be affected.

Almost all of the estimated losses of birds are of songbirds (98.7% at Norman Wells, 92% at Fort Simpson). Sparrows (36.1%), warblers (35.8%) and thrushes (13.6%) are estimated to lose the largest numbers of breeding birds (Table 46). Of species groups other than passerines, woodpeckers (3.8%) are estimated to lose the largest number of breeding pairs (Table 47).

Table 45. Estimated amount of habitat loss and bird species loss along a 200 km length of a proposed 50 m wide pipeline corridor centred on Norman Wells, NT.

Rank	Bird Species	Mean Pairs per ha	Habitat Loss (ha)	Number of Pairs Lost
1	CHSP	0.19	397.34	98.13
2	SWTH	0.31	313.87	61.42
3	LISP	0.19	380.31	61.4
4	YRWA	0.26	313.87	53.68
5	PAWA	0.11	380.31	51.55
6	OCWA	0.20	397.34	48.97
7	DEJU	0.12	397.34	49.48
8	WCSP	0.16	380.31	42.15
9	BPLW	0.06	599.41	31.19
10	HETH	0.06	380.31	25.6
11	SAVS	0.03	83.47	23.17
12	GRJA	0.07	296.84	22.12
13	TEWA	0.15	94.77	18.31
14	RCKI	0.06	296.84	12.31
15	MAGW	0.11	94.77	11.97
16	CCSP	0.11	83.47	9.54
17	BOWX	0.03	296.84	8.08
18	PIGR	0.03	296.84	8.08
19	WAVI	0.14	94.77	6.29

20	AMRO	0.03	219.1	5.96
21	ALFL	0.07	83.47	5.45
22	BAWW	0.10	94.77	4.9
23	FOSP	0.03	244.68	7.58
24	LEYE	0.03	83.47	2.73
25	NOWA	0.03	83.47	2.73
26	SWSP	0.03	83.47	2.73
27	BOCH	0.03	77.74	2.12
28	WETA	0.03	77.74	2.12
29	YBSA	0.03	77.74	2.12
30	CORE	0.02	83.47	1.36
31	HAWO	0.02	83.47	1.36
32	STGR	0.02	83.47	1.36
33	TRES	0.02	83.47	1.36
34	WISN	0.02	83.47	1.36
Total		**0.08**	**7122.02**	**688.68**

Table 46. Estimated amount of habitat loss and bird species loss along a 200 km length of proposed 50 m wide pipeline corridor centred on Fort Simpson, NT.

Rank	Bird Species	Mean Pairs per ha ±SD (n)	Habitat Loss (ha)	Number of Pairs Lost
1	TEWA	0.45	521.74	156.92
2	CHSP	0.20	492.27	88.55
3	YRWA	0.19	432.34	81.44
4	SWSP	0.65	89.4	58.38
5	LISP	0.22	368.38	57.66
6	OVEN	0.41	153.36	54.35
7	SWTH	0.15	432.34	53.51
8	YBSA	0.66	92.63	52.24
9	PAWA	0.18	278.98	51.24
10	RCKI	0.12	342.14	50.71
11	LEFL	1.55	29.47	45.71
12	DEJU	0.11	342.14	45.01
13	CCSP	0.49	89.4	43.79
14	COYE	0.49	89.4	43.79
15	REVI	0.90	29.47	26.46
16	GRJA	0.08	278.98	22.77
17	HETH	0.07	339.71	22.04
18	WTSP	0.06	368.38	18.69
19	AMRO	0.08	182.03	14.87
20	LCSP	0.16	89.4	14.60
21	WETA	0.12	92.63	12.72
22	TTWO	0.04	278.98	11.39
23	YBFL	0.04	278.98	11.39
24	CMWA	0.05	342.14	10.85

25	BAWW	0.12	90.2	9.77
26	MAGW	0.08	92.63	7.57
27	ALFL	0.08	89.4	7.30
28	BOCH	0.02	278.98	5.69
29	LEYE	0.02	278.98	5.69
30	PIGR	0.02	278.98	5.69
31	SPGR	0.02	278.98	5.69
32	BBWA	0.08	63.16	5.16
33	BHVI	0.08	60.73	4.96
34	WAVI	0.16	29.47	4.81
35	AMRE	0.08	29.47	2.41
36	DOWO	0.08	29.47	2.41
37	FOSP	0.08	29.47	2.41
38	NOWA	0.08	29.47	2.41
39	RUGR	0.08	29.47	2.41
Total		**0.22**	**7723.55**	**1123.46**

Table 47. Estimated numbers of breeding pairs, by species groups, to be lost to the pipeline project in 200 km sections at Norman wells and Fort Simpson.

	Norman Wells	**Fort Simpson**	**Total % loss (n=1812)**
Sparrows	306	348	36.1
Warblers	223	426	35.8
Thrushes	106	141	13.6
Woodpeckers	3	66	3.8
Flycatchers	5	64	3.8
Jays	22	23	2.5
Vireos	6	36	2.2
Chickadees	2	6	< 1.0
Shorebirds	4	6	< 1.0
Grouse	1	8	< 1.0
Waxwings	8	0	< 1.0
Swallows	1	0	< 1.0

Species at risk

Of the 75 species of birds detected during spot map surveys in 2004, and 49 species that were estimated to lose habitat and breeding pairs, none have been assessed as being at risk federally (COSEWIC 2004). However, some species that are predicted to lose habitat and breeding pairs are listed as sensitive by the Northwest Territories (Northwest Territories Wildlife and Fisheries 2000) and/or at risk by neighbouring jurisdictions (Table 48).

Table 48. Songbirds and other birds found in the Mackenzie Valley that are considered at risk in Northwest Territories, British Columbia and/or Alberta.

	At risk status		
Species	**Northwest Territories**[1]	**British Columbia**[2]	**Alberta**[3]
Sandhill Crane	Secure	Blue	Sensitive
Sharp-tailed Grouse	Secure	Blue	Sensitive
Lesser Yellowlegs	Sensitive	Not at risk	Secure
Wilson's Snipe	Sensitive	Not at risk	Secure
Great Gray Owl	Secure	Not at risk	Sensitive
Short-eared Owl	Sensitive	Blue	May be at risk
Black-backed Woodpecker	Secure	Not at risk	Sensitive
Northern Flicker	Sensitive	Not at risk	Secure
Olive-sided Flycatcher	Sensitive	Not at risk	Secure
Barn Swallow	Sensitive	Not at risk	Secure
Bank Swallow	Sensitive	Not at risk	Secure
Boreal Chickadee	Sensitive	Not at risk	Secure
American Pipit	Sensitive	Not at risk	Secure
Harris' Sparrow	Sensitive	Not at risk	Secure
White-throated Sparrow	Sensitive	Not at risk	Secure
American Tree Sparrow	Sensitive	Not at risk	Secure
Western Tanager	Secure	Not at risk	Sensitive
Blackpoll Warbler	Sensitive	Not at risk	Secure
Bay-breasted Warbler	Undetermined	Red	Sensitive
Cape May Warbler	Undetermined	Red	Sensitive
Canada Warbler	Undetermined	Blue	Sensitive
Rusty Blackbird	Sensitive	Not at risk	Secure

[1] Northwest Territories Wildlife and Fisheries, http://www.nwtwildlife.rwed.gov.nt.ca/monitoring/

[2] BC Ministry of Sustainable Resource Management http://srmwww.gov.bc.ca/atrisk/

[3] Alberta Ministry of Sustainable Resource Development http://www3.gov.ab.ca/srd/fw/speciesatrisk/birds.html

Birds with high conservation concern in Northern Forests

Several species of landbirds with high conservation concern in the Boreal Taiga Plains, according to Partners in Flight (Rich et al. 2004) were detected during spot map surveys in 2004. Two species are on the Watch List, 16 species have a high percentage of their global population in northern forests and three species have a high percentage of their western hemisphere populations in the northern forest (Table 49).

Table 49. List of landbirds with high conservation concern in the Northern Forest according to Partners in Flight (Rich et al. 2004).

Watch List	High global population	High western hemisphere population
Bay-breasted Warbler	Spruce Grouse	Bohemian Waxwing
Canada Warbler	Yellow-bellied Sapsucker	Pine Grosbeak
	Black-backed Woodpecker	White-winged Crossbill
	Yellow-bellied Flycatcher	
	Alder Flycatcher	
	Blue-headed Vireo	
	Gray Jay	
	Boreal Chickadee	
	Tennessee Warbler	
	Magnolia Warbler	
	Cape May Warbler	
	Palm Warbler	
	Mourning Warbler	
	Lincoln's Sparrow	
	Swamp Sparrow	
	White-throated Sparrow	

However, 17 of the 21 species listed in Table 49, have higher conservation concern in northern forests according to Partners in Flight, and are expected to lose habitat and breeding pairs to the pipeline development (Table 50). These 17 species account for 37.3% of the number of breeding pairs estimated to be lost. The other 4 species were detected during spot mapping surveys but were either determined to be off grid or not territorial and were not counted for habitat and breeding pair analysis purposes. In addition, 4 of these bird species are experiencing declines in BBS counts in the boreal forest (Table 50; Appendix 16).

Table 50. Estimated loss of breeding pairs, and global population sizes, for species that have high conservation concern in Northern Forests according to Partners in Flight (Rich et al. 2004). = declining BBS trends (Blancher 2003).

Species	Estimated loss of breeding pairs[1]			
	Fort Simpson	Norman Wells	Total	Global population[2]
Spruce Grouse	6	0	6	1,200,000
Yellow-bellied Sapsucker	52	2	54	9,200,000
Black-backed Woodpecker	0	0	0	1,300,000
Yellow-bellied Flycatcher	11	0	11	6,200,000
Alder Flycatcher	7	5	12	49,000,000
Blue-headed Vireo	5	0	5	6,900,0000

Gray Jay	23	22	5	16,000,000
Boreal Chickadee	6	2	45	7,800,000
Bohemian Waxwing	0	8	8	2,800,000
Tennessee Warbler	157	18	175	62,000,000
Magnolia Warbler	8	12	20	32,000,000
Cape May Warbler	11	0	11	3,200,000
Palm Warbler	51	52	103	23,000,000
Bay-breasted Warbler	5	0	5	3,100,000
Mourning Warbler	0	0	0	7,000,000
Canada Warbler	0	0	0	1,400,000
Lincoln's Sparrow	58	61	119	39,000,000
Swamp Sparrow	58	3	61	9,000,000
White-throated Sparrow	19	0	19	140,000,000
Pine Grosbeak	6	8	14	4,400,000
White-winged Crossbill	0	0	0	41,000,000
Total	483	193	676	
% of lost pairs	43.1 (n=1123)	28.1 (n=689)	37.3	

[1] Rounded to nearest whole number

[2] From Rich et al. 2004

DISCUSSION

Numbers of birds that would be displaced by lost habitat

The primary objective of this project is to estimate the impact on birds of the Mackenzie Gas Project. Important impacts for birds essentially boil down to how much habitat is lost, how many birds are estimated to be displaced and are there any biological or conservation effects on populations. The 1812 breeding pairs which are estimated to be lost are distributed over 400 kilometres and equates to 4.53 breeding pairs/linear km of pipeline.

While the total number of breeding pairs (1812) estimated to be lost in the study areas seems large, the scale of the project should be considered when estimating impacts to birds. If estimated losses were extrapolated over the entire 1,300 km length of the pipeline, then a total of 5,889 breeding pairs, or over 10,000 individual birds would be lost. However, it would be unwise to do so as bird habitat and community composition and densities change markedly in the NWT from south to north. However, even if densities are lower in other segments of the pipeline route, several thousand breeding pairs can be expected to be displaced. Literature from studies of fragmentation does not support the notion that birds displaced will "just go elsewhere". Often, birds displaced from a disturbance crowd into nearby habitat for the year after disturbance, with unknown reproductive success, and then disappear from the local population (Schmiegelow et al 1997, p. 1921). Until further evidence is presented, it is most likely that the loss of habitat translates directly to a decrease in populations.

Habitat for a few other species (e.g., Lesser Yellowlegs, Wilson's Snipe, Savannah Sparrow), may be created through the clearing of forest and shrubbery. Some species, such as Alder Flycatcher (tall shrubby edge habitat), Lincoln's Sparrow (moist, semi-open with shrub habitat), or White-throated Sparrow (shrubby edge habitat) may be able to use the pipeline clearings after certain amounts of successional revegetation takes place.

Species at risk

No federal species at risk were detected during spot mapping surveys in 2004. The NWT has a risk classification system similar to Alberta where species are assessed mainly as "secure, sensitive, or unclassified" (see Table 47). Many of the sensitive species are negatively impacted by forest removal as they are forest-dependent. However, only 5 "sensitive" species in the NWT are estimated by this study to lose habitat and breeding pairs:

Blackpoll Warbler	31 pairs	380 ha habitat
White-throated Sparrow	19 pairs	368 ha habitat
Lesser Yellowlegs	9 pairs	362 ha habitat
Boreal Chickadee	8 pairs	357 ha habitat
Wilson's Snipe	1 pair	83 ha habitat

Estimated losses for species (Bay-breasted Warbler, Cape May Warbler, Canada Warbler, Western Tanager, Black-backed Woodpecker, and Great Gray Owl) that are considered at risk in neighbouring jurisdictions such as British Columbia and Alberta, are small. Two species at risk from British Columbia or Alberta may benefit from pipeline clearings that increase more open habitat in forested areas (Sharp-tailed Grouse: Campbell et al. 1990; Connelly et al. 1998), or are likely to suffer little loss of breeding habitat, but may suffer disturbance effects (Sandhill Cranes: Cooper 1996).

Species that are listed by Partners in Flight as having high conservation concern in Northern Forests and are estimated to suffer losses from the pipeline project are likely of more conservation concern than species not listed. Watch List species have multiple causes for concern, wide ranges but declining populations, restricted ranges or small population sizes. Other categories reflect the importance of northern forests to global populations (Rich 2004). Most of the species listed in Table 46 will be negatively impacted by clearing of forested habitat for the pipeline. All of the species mentioned in Table 46 likely warrant higher levels of conservation concern in the NWT than other species detected during surveys.

Other

Differences in the estimated loss of species between Norman Wells and Fort Simpson can be largely explained by differences in habitat structure and the geographic ranges of the species. Tennessee Warbler, Swamp Sparrow and Yellow-bellied Sapsucker are many times more abundant at Fort Simpson than at Norman Wells. Several species including Ovenbird, Common Yellowthroat, Least Flycatcher, White-throated Sparrow and Red-eyed Vireo are fairly common at Fort Simpson but were absent further north at Norman Wells.

In addition to losses associated with habitat loss, direct mortality of birds may occur during construction or maintenance, especially if construction occurs during the breeding season (Jalkotzy et al. 1997, Howard and Postovit 1987). Nests with eggs or young may be destroyed and adults may also be at risk. Potential impacts would be avoided or reduced if construction occurred outside the breeding season.

Additional effects on birds

Except for the predicted loss of habitat, there is an information gap regarding the impact of pipeline development in the Mackenzie Valley There are at least 4 other major ecological events or processes related to habitat fragmentation impacts on forest birds:

- Increased predation of nests and nestlings;
- Increased parasitism of nests by Brown-headed Cowbirds;
- Decreased/increased dispersal success between habitat fragments, and
- Potential for changed reproductive success from habitat changes (e.g., desiccation near edges, changed vegetation and growth near edges).

Increased nest predation along the pipeline is possible, but is an unknown. However, many studies have linked corridors through forests with increased predation of bird nests (e.g., Hartley and Hunter 1998; Dijak and Thompson 2000; Woodward et al. 2001). Increased parasitism by Brown-headed Cowbirds is unlikely, as few cowbirds occur in the NWT high cowbird populations are usually associated with agricultural development. Decreased dispersal success will not likely occur until the landscape is much more disturbed and broken up by permanent clearings. Some species such as Sharp-tailed Grouse may disperse more easily along open corridors. Finally, the potential for changed reproductive success is a subtle effect that is likely not relevant at any population level given the current scale of development, although local effects may be felt along the corridor right of way.

CONCLUSIONS

Habitat

Critical habitats for birds should be identified along the pipeline corridor and special mitigation measures should be implemented to reduce impacts.

Potential impacts will be partially minimized where the pipeline follows an existing pipeline corridor. Extensive amounts of early seral vegetation will be created where forest is cleared for the pipeline corridor. Impacts on birds will be positive for some open habitat birds and negative for interior forest birds. Impacts on adjacent ecosystems are expected to be negligible. The pipeline corridor will not act as a barrier to bird movement, but will facilitate movements of some species.

Edge effects will be introduced in forests cleared for the pipeline corridor, which may have negative impacts on breeding success of some individual birds, though without further study this effect appears to be slight. Potential effects will be minimized where the pipeline corridor follows an existing corridor, although the corridor clearing may be wider than it is currently.

Some old forest will be lost but the area amount is small over the scale of the pipeline route. Possible impacts from sedimentation and public access are likely negligible.

Potential impacts to aquatic systems from pollution are present and mitigation measures should be in place especially where the corridor crosses wetlands, rivers, or critical bird habitat.

Bird populations

Several thousand breeding pairs of at least 49 species of landbirds can be expected to be displaced by development of the 1,300 km pipeline corridor. A few additional species can be expected to be impacted because their ranges in the Mackenzie Valley are outside the two study areas, especially those species that occur only near the northern and southern terminus of the pipeline route.

None of the species covered in this report are federal species at risk. Several species are listed as having high conservation concern by Partners in Flight due to their dependence on northern forests, and a few of these species are experiencing declines according to BBS data.

CHAPTER 4 – MANAGEMENT IMPLICATIONS AND RECOMENDATIONS

ADAPTIVE LANDSCAPE MANAGEMENT

Adaptive landscape management is dependent on an analysis of landscape-level patterns and processes (Wiens 1996; Peters et al. 1997), and has the goal of sustaining ecological processes, while also serving the multiple needs and values of society (Booth et al. 1993; Thompson and Welsh 1993). Adaptive management utilizes ecological understandings of the landscape in the development activities in attempt with an emphasis on effectively retaining identified forest values such as characteristic landscape structure and biological diversity through time (Galindo-Leal and Bunnell 1995; Norton 1996). Effectiveness monitoring in tandem with landscape management activities (Niemelä 2000), can allow evaluation of success of landscape management priorities for large-scale landscape management projects such as the Mackenzie Gas Project.

One approach to landscape management is an emulation of the natural disturbance regime (Booth et al. 1993; Attiwell 1994; Niemelä 1999; Bergeron et al. 2003). It is thought that by retaining a "natural" range of structural variability in the ecosystem, including late-successional forest characteristics (such as larger diameter trees and multi-layered canopy structure), may be an effective way to maintain ecosystem integrity as well as sustain a range of biological legacies (Hansen et al. 1991; Haila et al. 1994; Franklin et al. 1997; Niemelä 1999). Baseline data on forest, shrubland, and wetland structure and associated biological community composition may assist in identifying landscape priorities as well as defining the link between functional roles of various biota and ecosystem processes (Bonan and Shugart 1989; Hansson 1992; Haila 1994).

The inherent variability in the natural disturbance patterns of boreal forest ecosystems provides landscape managers with great flexibility in matching natural and anthropogenic disturbance regimes (Larsen 1980; McCullough 1998). Additionally, much of the boreal biota is considered generalist in its behaviour and apparently adaptable to boreal ecosystem latent change (e.g., Schmiegelow et al. 1997). Any land management that attempts to mimic natural disturbance would be beneficial compared to those that do not.

There are many mitigation strategies that can be implemented during any construction project to minimize potential negative effects on bird habitat. Several of these strategies may have application in the Mackenzie Valley, with a cumulative positive impact on bird habitat that may be quite large along the length of the project, and are discussed briefly below.

Sensitive Wetlands

Wetlands are often some of the most important habitat for breeding and migrating birds. Sensitive wetlands should be identified and mitigation measures should be planned for prior to construction:

- Route the pipeline away from sensitive wetlands where possible.
- Control erosion during construction through use of rip-rap, sumps, filter-fabric, and rapid revegetation of disturbed soils. Avoid disturbing unstable and highly erodable soils in the vicinity of sensitive wetlands.

- Make liberal use of vegetated ditches and constructed wetlands as "biofilters" to remove contaminants and sediments from run-off waters before they enter sensitive wetlands.

- Minimize the number of creek crossings, and cross at right angle to the water flow where possible.

- Train staff and construction workers on responsible behaviour near sensitive wetlands, lakes and streams.

- Monitor and extirpate invasive noxious weed species, in all wetland areas and replace, if necessary, with indigenous plant species.

Riparian habitat

Riparian habitat is often a relatively rich habitat for breeding birds, often supporting a higher diversity of birds than the surrounding uplands. Mitigation measures to reduce impacts to riparian habitats should be routinely implemented along the length of the pipeline:

- Locate main facilities outside riparian zone.

- Avoid road development in the riparian zone.

- Employ bioengineering techniques (e.g. live brush sills, brush grids or timber cribs) and conventional engineering techniques to stabilize stream banks and prevent slumping and erosion.

- Locate all construction staging areas outside of wetland and riparian zones.

- Restore the natural grade of river banks and floodplains after construction.

- Revegetate all disturbed areas with native wetland herbaceous and woody plant species to restore habitat complexity. Only use commercially available wetland vegetation species when native species are unavailable.

Wildlife tree retention

Some trees are more valuable to birds than others. Wildlife trees, those trees that are dead, or decayed, or that have special structural features, which provide relatively rare habitat for certain bird species should be retained wherever possible:

- Avoid felling dead or decayed trees with sign of use by woodpeckers or raptors outside of the cleared corridor within 1 tree length of the edge of the cleared corridor.

- Assess large dead or decayed trees for soundness and fell only those trees that are deemed to pose potential threats to construction workers.

RETENTION HARVESTING OF THE PIPELINE CORRIDOR

Development of a new pipeline corridor through forested parts of the southern NWT may open up new areas for forest harvesting. If so, potential impacts to birds from the pipeline development could be exacerbated. From an ecological perspective, retention harvesting in areas adjacent to the pipeline corridor is more likely to maintain ecosystem integrity as well as biological value to a host of organisms. Retaining structure, such as multi-layered canopies, abundant decaying coarse woody material and large diameter seed trees, in the harvested landscape utilizes benefits of already established biological legacies (Hansen et al. 1991; Hansson 1992; Franklin et al. 1997). Similar in approach to natural disturbance emulation, retention-harvesting techniques endeavour to incorporate a range of forest characteristics and landscape structure into landscape management practices. Maintaining a range of biological structure on the harvested landscape may also retain great amounts of natural variability of microclimates and forest conditions (Deans et al. 2003).

Retention harvesting techniques used to enhance the structural connectivity across the managed landscape may also maintain greater amounts of habitat connectivity and ameliorate landscape fragmentation and edge effects of clearing large areas of forest structure from the landscape (Noss 1993; Fahrig 1997; Franklin et al. 1997). For purposes of conserving biological diversity, retention areas of contiguous forest in close proximity to clearings are a sound investment in the future productivity and integrity of the regional landscape (Franklin 1993; Peterson et al. 1998; Noss 1999).

EDGE EFFECTS ON A FRAGMENTED LANDSCAPE

As habitats become fragmented, more edges are created, reducing habitat suitability for forest interior bird specialists that avoid edges, while providing more habitat for species that prefer open or forest edge habitats (Austen et al. 2001). Edge species tend to move into areas with fragmented habitats. Roads, transmission lines, seismic lines and pipelines create corridors that allow such species access to new areas.

Beyond predation, other changes to other aspects of habitat quality may negatively affect interior species. Abiotic factors vary with edge and may result in different patterns of use. An altered microclimate (wind, temperature and moisture) may change forage patterns near forest edge habitat (Dolby and Grub 1999). Foraging opportunities may also be altered if insect populations are reduced (Robinson 1998).

Whether pipeline corridors actually create edge effects for native wildlife species requires further investigation (Goldingay and Whelan 1997). One study in northern Alberta, showed that bird species richness was not different in areas with pipeline corridors and areas without, but that a few species showed preferences for one or the other (Fleming 2001). The proposed pipeline project will create a new corridor along most of its route, although a large proportion will follow an existing corridor. Fleming's (2001) study showed that some species are more sensitive to corridors as the width of the corridor increases. The increased width may result in some additional changes in plant composition (McFarlane 2002), and may further enhance the attractiveness to predatory species and may further alter abiotic factors.

BIRD COMMUNITY RESPONSES

Bird communities are well known to respond to sudden changes in their environment, especially when changes are related to fragmentation of habitat. Fragmentation of habitat has been well documented as an important issue in bird conservation (e.g., Robbins et al. 1989; Hagan and Johnston 1992; Rappole and McDonald 1994; Martin and Finch 1995; Askins 2000). Habitat fragmentation contributes to habitat loss, through outright reduction in available habitat. In addition, the quality of the remaining habitat is altered as both biotic (suites of species) and abiotic (temperature and moisture) factors are affected in the remaining patches of habitat (Scott 1994). Although a single project (i.e., forestry, road construction, pipeline, etc.) may affect only a small portion of the total habitat available, the cumulative impact of multiple projects has to be considered (Keyser et al. 1998).

Impacts on interior forest birds are most often described as fragmentation from logging, roads, transportation corridors, utility corridors, and others. These reduce habitat suitability for forest interior species while providing more habitat for species that prefer forest edge (e.g., Austen et al. 2001), or open habitats (Schieck et al. 2000).

Many studies focus on effects in areas with large degrees of fragmentation from linear corridors (e.g., eastern North America; Rich et al. 1992; Morneau et al. 1999), while studies on effects of any habitat fragmentation on birds in remote northern areas (e.g., Schmiegelow et al. 1997) such as the NWT are few in number. Impacts on bird communities from pipeline developments is poorly known, but could be expected to approximate effects felt from other linear corridors of similar widths. For example, in northern and central British Columbia, changes in habitat from development of transportation and utility corridors and associated human developments is thought to have encouraged range expansions along those corridors for species (e.g., Least Flycatcher, Blue Jay) that thrive in human-altered landscapes but which were geographically isolated by mountain ranges (Campbell et al. 1997). Similar effects could be anticipated for the Mackenzie Gas Pipeline if associated human developments occur.

One study in eastern North America, found significant effects on forest interior birds from corridors only 8 m in width, and even greater effects from corridors up to 23 m in width (Rich et al. 1992). Small linear corridors (e.g., 4-6 m wide seismic lines) are common in northern Alberta, northern British Columbia (where species like White-throated Sparrow are known to occur in relatively high abundance, Campbell et al. 2001) and southwestern NWT, yet effects of seismic lines on forest birds has not been well studied (C. Machtans pers. comm.). It is even more logical to expect effects on bird communities (e.g., increasing abundances of edge or more open habitat species such as White-throated Sparrow, Alder Flycatcher, LeConte's Sparrow and local decreases in forest interior species) from much wider corridors such as will be created by the Mackenzie Gas Pipeline. Whether or not those effects are significant remains uncertain but will be largely dependent on the response of nest predators (e.g., corvids) and parasites (e.g., cowbirds) to the new corridor, and to the extent that species move into newly created edge and open habitats. A major study that will start in 2005 will attempt to answer this question specifically for the pipelines in the NWT (C. Machtans, pers. comm.).

ECOLOGICAL INDICATORS

The possibility of matching landscape management activities with the maintenance of boreal biota appears reasonable; however, there is a need to establish criteria for monitoring the effectiveness of any methods (Niemelä 2000). Because an entire ecosystem could never be monitored due to cost and time constraints, the use of ecological indicators (biological and physical) of ecosystem condition has been widely recognized (e.g., Noss 1990; Haila 1994; Norton 1996; Niemelä 2000).

The challenge of identifying appropriate indicators to monitor ecosystem health as well as the effectiveness of landscape management activities is complex (e.g., Williams and Gaston 1994; Hilty and Merelender 2000). However, if development projects like the Mackenzie Gas Pipeline have sustainability as a priority, then long term ecological monitoring should be a priority (Noss 1999; Niemelä 2000). Several authors have suggested that the selection of ecological indicators should focus on components of biodiversity that: (1) are likely to respond strongly and quickly to changes in forest landscapes both at the stand and landscape levels; (2) occur simultaneously in large number of species; (3) are relatively easy to survey; (4) can be surveyed at relatively low cost; (5) are well known with respect to their ecology; and (6) encompass a range of functional groups in the ecosystem (Noss 1990; Noss 1999; Niemelä 2000).

Ecological communities or ecosystems are sensitive to stress, from both natural and man-made activities. Ecological assessments and monitoring programs often rely on indicators to evaluate environmental conditions. Ecological indicators are selected to compare characteristics from impacted communities to those of reference communities to determine if a community has been negatively impacted. Such indicators provide the most efficient tools for determining what to monitor and how to interpret what is found. Several of these ecological indicator species are likely to be birds, but each indicator would have to be rigorously chosen and tested for its validity. We therefore recommend initiation of long term studies on the impacts of linear corridors on birds in the northern boreal forest.

CONSIDERATIONS FOR THE FUTURE LANDSCAPE DEVELOPMENTS

The development of a Mackenzie Valley gas pipeline represents a great opportunity to reach global energy markets with concurrent evaluations of the benefits and consequences of the development across the Northwest Territory landscape. In recognition that environmental issues are complex and not restricted to political or jurisdictional boundaries, but are shared among nations, an ecological perspective is necessary to provide a common basis for understanding.

In the face of rapidly expanding demands for natural resources and increasing pressures for development projects to supply energy markets efficiently, the need for adaptive approaches to manage environmental and associated socio-economic concerns has never been more pertinent. Best management approaches to sustainable development, recognized as one that encompasses a range of socio-economic and ecological considerations (Brundtland 1987), calls for increased co-operation with industry. For "sustainable developments" like the Mackenzie Valley gas pipeline project to be truly sustainable, the environmental costs and benefits require consideration directly by industry.

The Mackenzie Gas Pipeline could be an example of industry taking responsibility for delivering a supply to market while administering ecological as well as social landscape considerations (Imperial Oil Resources Ventures Ltd 2003). Evaluating the range of socio-economic and ecological concerns is one way that industry may take responsibility for the benefits as well as the costs of natural resource extraction while enhancing and/or restoring public confidence that the long-term economic benefits out-weigh possible ecological impacts.

Even though short term edge effects in forest stands adjacent to the pipeline corridor may be observed, an understanding of the longer term ecological impacts on ecosystem function and biological diversity may be more important, especially in the face of possible climate change. The complexity of stochastic changes and variable trends in the songbird community, demonstrated in this study, as in others (e.g., Schmiegelow and Hannon 1993; McGarigal and McComb 1995; Schmiegelow et al. 1997) suggest that both determining the ecological effects of management practices and identifying suitable management indicators may not be an easy task. Nonetheless, the use of songbird species as proxies of ecosystem health may be a good starting point.

The development of a pipeline extension across the Mackenzie Valley landscape as well as possible future developments in Canada's Boreal Taiga Plains provides an opportunity to gain knowledge and implement sustainable practices. The potential for adoption of adaptive management approaches, effectiveness monitoring to evaluate successes, and reporting on sustainable landscape management practices to build and restore public confidence, is great. Sustaining boreal ecosystems should be viewed as inherently important to the overall success of the Mackenzie Valley pipeline.

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APPENDIX 1: 4-letter bird species codes for 2004 spot mapping plots near Fort Simpson, NT.

BBS CODE	COMMON NAME
ALFL	Alder Flycatcher
AMBI	American Bittern
AMCR	American Crow
AMKE	American Kestrel
AMRE	America Redstart
AMRO	American Robin
ATSP	American Tree Sparrow
BAOW	Barred Owl
BAT	Bat Species
BAWW	Black-and-White Warbler
BBWA	Bay-breasted Warbler
BBWO	Black-backed Woodpecker
BCCH	Black-capped Chickadee
BHVI	Blue-headed Vireo
BOCH	Boreal Chickadee
BOWX	Bohemian Waxwing
BPLW	Blackpoll Warbler
CAGO	Canada Goose
CAWA	Canada Warbler
CCSP	Clay-colored Sparrow
CEWX	Cedar Waxwing
CHSP	Chipping Sparrow
CMWA	Cape May Warbler
COLO	Common Loon
CONI	Common Nighthawk
CONW	Connecticut Warbler
CORA	Common Raven
COYE	Common Yellowthroat
DEJU	Dark-eyed Junco
DOWO	Downy Woodpecker
EAPH	Eastern Phoebe
EVGR	Evening Grosbeak
FOSP	Fox Sparrow
GCKI	Golden-crowned Kinglet
GCTH	Gray-cheeked Thrush
GRJA	Gray Jay
HAFL	Hammond's Flycatcher
HAWO	Hairy Woodpecker
HETH	Hermit Thrush
LEFL	Least Flycatcher
LISP	Lincoln's Sparrow
MAGW	Magnolia Warbler
MOWA	Mourning Warbler
NOFL	Northern Flicker
NOSK	Northern Shrike
NOWA	Northern Waterthrush
OCWA	Orange-crowned Warbler
OSFL	Olive-sided Flycatcher
OVEN	Ovenbird
PAWA	Palm Warbler
PHVI	Philadelphia Vireo
PICO	Picoides Sp
PIGR	Pine Grosbeak
PISI	Pine Siskin
PIWO	Pileated Woodpecker
PUFI	Purple Finch
RBGR	Rose-breasted Grosbeak
SAVS	Savannah Sparrow
SPGR	Spruce Grouse
SWSP	Swamp Sparrow
SWTH	Swainson's Thrush
TESW	Tree Swallow
TEWA	Tennessee Warbler
TRUS	Trumpeter Swan
TTWO	Three-toed Woodpecker
UNKN	Unknown
VATH	Varied Thrush
WAVI	Warbling Vireo
WCSP	White-crowned Sparrow
WETA	Western Tanager
WIWA	Wilson's warbler
WTSP	White-throated Sparrow
WWCR	White-winged Crossbill
WWPE	Western Wood Peewee
YBFL	Yellow-bellied Flycatcher
YBSA	Yellow-bellied Sapsucker
YRWA	Yellow-rumped Warbler
YWAR	Yellow Warbler

APPENDIX 2: 4-letter bird species codes for 2004 spot mapping plots near Norman Wells, NT.

BBS CODE	COMMON NAME
ALFL	Alder Flycatcher
AMBI	American Bittern
AMCR	American Crow
AMKE	American Kestrel
AMRE	America Redstart
AMRO	American Robin
ATTW	A. Three-toed Woodpecker
ATSP	American Tree Sparrow
BAT	Bat Species
BAWW	Black-and-White Warbler
BBWA	Bay-breasted Warbler
BBWO	Black-backed Woodpecker
BCCH	Black-capped Chickadee
BHVI	Blue-headed Vireo
BOCH	Boreal Chickadee
BOWX	Bohemian Waxwing
BPLW	Blackpoll Warbler
CAGO	Canada Goose
CCSP	Clay-colored Sparrow
CEWX	Cedar Waxwing
CHSP	Chipping Sparrow
CMWA	Cape May Warbler
COLO	Common Loon
CONI	Common Nighthawk
CORA	Common Raven
COYE	Common Yellowthroat
DEJU	Dark-eyed Junco
DOWO	Downy Woodpecker
EAPH	Eastern Phoebe
EVGR	Evening Grosbeak
FOSP	Fox Sparrow
GCKI	Golden-crowned Kinglet
GCTH	Gray-cheeked Thrush
GRJA	Gray Jay
HAWO	Hairy Woodpecker
HETH	Hermit Thrush
LEFL	Least Flycatcher
LISP	Lincoln's Sparrow
MAGW	Magnolia Warbler
NOFL	Northern Flicker
NOSK	Northern Shrike
NOWA	Northern Waterthrush
OCWA	Orange-crowned Warbler
OSFL	Olive-sided Flycatcher
OVEN	Ovenbird
PAWA	Palm Warbler
PICO	Picoides Sp
PIGR	Pine Grosbeak
PISI	Pine Siskin
PIWO	Pileated Woodpecker
PUFI	Purple Finch
RBGR	Rose-breasted Grosbeak
RBNU	Red-breasted Nuthatch
RCKI	Ruby-crowned Kinglet
RECR	Red Crossbill
RESQ	Red Squirrel
REVI	Red-eyed Vireo
RNGR	Red-necked Grebe
RUBL	Rusty Blackbird
RUGR	Ruffed Grouse
SAVS	Savannah Sparrow
SPGR	Spruce Grouse
SWSP	Swamp Sparrow
SWTH	Swainson's Thrush
TESW	Tree Swallow
TEWA	Tennessee Warbler
TRUS	Trumpeter Swan
UNKN	Unknown
VATH	Varied Thrush
WAVI	Warbling Vireo
WCSP	White-crowned Sparrow
WETA	Western Tanager
WIWA	Wilson's warbler
WTSP	White-throated Sparrow
WWCR	White-winged Crossbill
WWPE	Western Wood Peewee
YBFL	Yellow-bellied Flycatcher
YBSA	Yellow-bellied Sapsucker
YRWA	Yellow-rumped Warbler
YWAR	Yellow Warbler

APPENDIX 3: 4-letter tree species codes for 2004 spot mapping habitat plots near Fort Simpson and Norman Wells, NT.

Trees		
POTR	Trembling aspen	*Populus tremuloides*
POBA	Balsam poplar	*Populus balsamifera*
PIBA	Jack pine	*Pinus banksiana*
PIGL	White spruce	*Picea glauc*
PIMA	Black spruce	*Picea mariana*
LALA	Tamarack	*Larix lacrina*
BEPA	Paper birch	*Betula papyrifera*
Shrubs		
ALCR	Green alder	*Alnus crispa*
BEGL	Dwarf birch	*Betula glandulosa*
SALI	Willow species	*Salix* spp.

APPENDIX 4: Estimated amount of habitat loss and bird species loss along a 200 km length of proposed 50 m wide pipeline corridor centred on Fort Simpson, NT.

Bird Species	Mean Pairs per ha ±SD (n)	Habitat Loss (ha)	Number of Pairs Lost	Habitat Type
TEWA	0.20 ±0.14(4)	278.98	56.93	Black Spruce-Open
TEWA	0.73(1)	63.16	46.40	White Spruce
TEWA	0.90(1)	29.47	26.46	Deciduous
TEWA	0.33(1)	60.73	19.83	Jack Pine
TEWA	0.08(1)	89.4	7.30	Low Shrubland
TEWA	**0.45**	**521.74**	**156.92**	
CHSP	0.16 ±0.09(4)	278.98	45.55	Black Spruce-Open
CHSP	0.41(1)	63.16	25.78	White Spruce
CHSP	0.16(1)	60.73	9.92	Jack Pine
CHSP	0.08(1)	89.4	7.30	Low Shrubland
CHSP	**0.20**	**492.27**	**88.55**	
YRWA	0.18 ±0.14(4)	278.98	51.24	Black Spruce-Open
YRWA	0.24(1)	63.16	15.47	White Spruce
YRWA	0.16(1)	29.47	4.81	Deciduous
YRWA	0.16(1)	60.73	9.92	Jack Pine
YRWA	**0.19**	**432.34**	**81.44**	
SWSP	0.65(1)	89.4	58.38	Low Shrubland
LISP	0.33(1)	89.4	29.19	Low Shrubland
LISP	0.10 ±0.08(4)	278.98	28.47	Black Spruce-Open
LISP	**0.22**	**368.38**	**57.66**	
OVEN	0.41(1)	60.73	24.79	Jack Pine
OVEN	0.65(1)	29.47	19.25	Deciduous
OVEN	0.16(1)	63.16	10.31	White Spruce
OVEN	**0.41**	**153.36**	**54.35**	
SWTH	0.10 ±0.04(4)	278.98	28.47	Black Spruce-Open
SWTH	0.16(1)	63.16	10.31	White Spruce
SWTH	0.16(1)	60.73	9.92	Jack Pine
SWTH	0.16(1)	29.47	4.81	Deciduous
SWTH	**0.15**	**432.34**	**53.51**	
YBSA	0.90(1)	29.47	26.46	Deciduous
YBSA	0.41(1)	63.16	25.78	White Spruce
YBSA	**0.66**	**92.63**	**52.24**	

Bird Species	Mean Pairs per ha ±SD (n)	Habitat Loss (ha)	Number of Pairs Lost	Habitat Type
PAWA	0.18 ±0.08(4)	278.98	51.24	Black Spruce-Open
RCKI	0.16 ±0.12(4)	278.98	45.55	Black Spruce-Open
RCKI	0.08(1)	63.16	5.16	White Spruce
RCKI	**0.12**	**342.14**	**50.71**	
LEFL	1.55(1)	29.47	45.71	Deciduous
DEJU	0.14 ±0.04(4)	278.98	39.85	Black Spruce-Open
DEJU	0.08(1)	63.16	5.16	White Spruce
DEJU	**0.11**	**342.14**	**45.01**	
CCSP	0.49(1)	89.4	43.79	Low Shrubland
COYE	0.49(1)	89.4	43.79	Low Shrubland
REVI	0.90(1)	29.47	26.46	Deciduous
GRJA	0.08 ±0.0(4)	278.98	22.77	Black Spruce-Open
HETH	0.06 ±0.08(4)	278.98	17.08	Black Spruce-Open
HETH	0.08(1)	60.73	4.96	Jack Pine
HETH	**0.07**	**339.71**	**22.04**	
WTSP	0.04 ±0.05(4)	278.98	11.39	Black Spruce-Open
WTSP	0.08(1)	89.4	7.30	Low Shrubland
WTSP	**0.06**	**368.38**	**18.69**	
AMRO	0.08(1)	89.4	7.30	Low Shrubland
AMRO	0.08(1)	63.16	5.16	White Spruce
AMRO	0.08(1)	29.47	2.41	Deciduous
AMRO	**0.08**	**182.03**	**14.87**	
LCSP	0.16(1)	89.4	14.60	Low Shrubland
WETA	0.16(1)	63.16	10.31	White Spruce
WETA	0.08(1)	29.47	2.41	Deciduous
WETA	**0.12**	**92.63**	**12.72**	
TTWO	0.04 ±0.05(4)	278.98	11.39	Black Spruce-Open
YBFL	0.04 ±0.05(4)	278.98	11.39	Black Spruce-Open
CMWA	0.02 ±0.04(4)	278.98	5.69	Black Spruce-Open
CMWA	0.08(1)	63.16	5.16	White Spruce
CMWA	**0.05**	**342.14**	**10.85**	

Bird Species	Mean Pairs per ha ±SD (n)	Habitat Loss (ha)	Number of Pairs Lost	Habitat Type
BAWW	0.08(1)	60.73	4.96	Jack Pine
BAWW	0.16(1)	29.47	4.81	Deciduous
BAWW	**0.12**	**90.2**	**9.77**	
MAGW	0.08(1)	63.16	5.16	White Spruce
MAGW	0.08(1)	29.47	2.41	Deciduous
MAGW	**0.08**	**92.63**	**7.57**	
ALFL	0.08(1)	89.4	7.30	Low Shrubland
BOCH	0.02 ±0.04(4)	278.98	5.69	Black Spruce-Open
LEYE	0.02 ±0.04(4)	278.98	5.69	Black Spruce-Open
PIGR	0.02 ±0.04(4)	278.98	5.69	Black Spruce-Open
SPGR	0.02 ±0.04(4)	278.98	5.69	Black Spruce-Open
BBWA	0.08(1)	63.16	5.16	White Spruce
BHVI	0.08(1)	60.73	4.96	Jack Pine
WAVI	0.16(1)	29.47	4.81	Deciduous
AMRE	0.08(1)	29.47	2.41	Deciduous
DOWO	0.08(1)	29.47	2.41	Deciduous
FOSP	0.08(1)	29.47	2.41	Deciduous
NOWA	0.08(1)	29.47	2.41	Deciduous
RUGR	0.08(1)	29.47	2.41	Deciduous

APPENDIX 5: Estimated amount of habitat loss and bird species loss along a 200 km length of proposed 50 m wide pipeline corridor centred on Norman Wells, NT.

Bird Species	Mean Pairs per ha ±SD (n)	Habitat Loss (ha)	Number of Pairs Lost	Habitat Type
CHSP	0.30 ±0.17(3)	219.1	65.58	Black Spruce-Open
CHSP	0.20 ±0.16(5)	83.47	16.35	Fire Regen-Low Shrubland
CHSP	0.19 ±0.09(3)	77.74	14.81	White Spruce
CHSP	0.08(1)	17.03	1.39	Deciduous
CHSP	**0.19**	**397.34**	**98.13**	
SWTH	0.14 ±0.17(3)	219.1	29.81	Black Spruce-Open
SWTH	0.30 ±0.17(3)	77.74	23.27	White Spruce
SWTH	0.49(1)	17.03	8.34	Deciduous
SWTH	**0.31**	**313.87**	**61.42**	
LISP	0.42 ±0.27(5)	83.47	35.43	Fire Regen-Low Shrubland
LISP	0.11 ±0.12(3)	219.1	23.85	Black Spruce-Open
LISP	0.03 ±0.05(3)	77.74	2.12	White Spruce
LISP	**0.19**	**380.31**	**61.4**	
YRWA	0.14 ±0.05(3)	219.1	29.81	Black Spruce-Open
YRWA	0.22 ±0.12(3)	77.74	16.92	White Spruce
YRWA	0.41(1)	17.03	6.95	Deciduous
YRWA	**0.26**	**313.87**	**53.68**	
PAWA	0.19 ±0.19(3)	219.1	41.73	Black Spruce-Open
PAWA	0.11 ±0.12(3)	77.74	8.46	White Spruce
PAWA	0.02 ±0.04(5)	83.47	1.36	Fire Regen-Low Shrubland
PAWA	**0.11**	**380.31**	**51.55**	
OCWA	0.11 ±0.05(3)	219.1	23.85	Black Spruce-Open
OCWA	0.16 ±0.08(3)	77.74	12.69	White Spruce
OCWA	0.49(1)	17.03	8.34	Deciduous
OCWA	0.05 ±0.11(5)	83.47	4.09	Fire Regen-Low Shrubland
OCWA	**0.20**	**397.34**	**48.97**	
DEJU	0.14 ±0.05(3)	219.1	29.81	Black Spruce-Open
DEJU	0.22 ±0.12(3)	77.74	16.92	White Spruce
DEJU	0.08(1)	17.03	1.39	Deciduous
DEJU	0.02 ±0.04(5)	83.47	1.36	Fire Regen-Low Shrubland
DEJU	**0.12**	**397.34**	**49.48**	

Bird Species	Mean Pairs per ha ±SD (n)	Habitat Loss (ha)	Number of Pairs Lost	Habitat Type
WCSP	0.41 ±0.06(5)	83.47	34.07	Fire Regen-Low Shrubland
WCSP	0.03 ±0.05(3)	219.1	5.96	Black Spruce-Open
WCSP	0.03 ±0.05(3)	77.74	2.12	White Spruce
WCSP	**0.16**	**380.31**	**42.15**	
BPLW	0.14 ±0.12(3)	77.74	10.58	White Spruce
BPLW	0.08 ±0.05(3)	219.1	17.89	Black Spruce-Open
BPLW	0.03 ±0.07(5)	83.47	2.73	Fire Regen-Low Shrubland
BPLW	**0.06**	**380.31**	**31.2**	
HETH	0.08(3)	219.1	17.89	Black Spruce-Open
HETH	0.08 ±0.08(3)	77.74	6.35	White Spruce
HETH	0.02 ±0.04(5)	83.47	1.36	Fire Regen-Low Shrubland
HETH	**0.06**	**380.31**	**25.6**	
SAVS	0.03 ±0.18(5)	83.47	23.17	Fire Regen-Low Shrubland
GRJA	0.08(3)	219.1	17.89	Black Spruce-Open
GRJA	0.05 ±0.05(3)	77.74	4.23	White Spruce
GRJA	**0.07**	**296.84**	**22.12**	
TEWA	0.22 ±0.24(3)	77.74	16.92	White Spruce
TEWA	0.08(1)	17.03	1.39	Deciduous
TEWA	**0.15**	**94.77**	**18.31**	
RCKI	0.08 ±0.08(3)	77.74	6.35	White Spruce
RCKI	0.03 ±0.05(3)	219.1	5.96	Black Spruce-Open
RCKI	**0.06**	**296.84**	**12.31**	
MAGW	0.14 ±0.24(3)	77.74	10.58	White Spruce
MAGW	0.08(1)	17.03	1.39	Deciduous
MAGW	**0.11**	**94.77**	**11.97**	
CCSP	0.11 ±0.16(5)	83.47	9.54	Fire Regen-Low Shrubland
BOWX	0.03 ±0.05(3)	219.1	5.96	Black Spruce-Open
BOWX	0.03 ±0.05(3)	77.74	2.12	White Spruce
BOWX	**0.03**	**296.84**	**8.08**	
PIGR	0.03 ±0.05(3)	219.1	5.96	Black Spruce-Open
PIGR	0.03 ±0.05(3)	77.74	2.12	White Spruce
PIGR	**0.03**	**296.84**	**8.08**	

Bird Species	Mean Pairs per ha ±SD (n)	Habitat Loss (ha)	Number of Pairs Lost	Habitat Type
WAVI	0.24(1)	17.03	4.17	Deciduous
WAVI	0.03 ±0.05(3)	77.74	2.12	White Spruce
WAVI	**0.14**	**94.77**	**6.29**	
AMRO	0.03 ±0.05(3)	219.1	5.96	Black Spruce-Open
ALFL	0.07 ±0.07(5)	83.47	5.45	Fire Regen-Low Shrubland
BAWW	0.16(1)	17.03	2.78	Deciduous
BAWW	0.03 ±0.05(3)	77.74	2.12	White Spruce
BAWW	**0.10**	**94.77**	**4.9**	
FOSP	0.03 ±0.04(5)	83.47	2.73	Fire Regen-Low Shrubland
FOSP	0.03 ±0.05(3)	77.74	2.12	White Spruce
FOSP	**0.03**	**161.21**	**4.85**	
LEYE	0.03 ±0.04(5)	83.47	2.73	Fire Regen-Low Shrubland
NOWA	0.03 ±0.04(5)	83.47	2.73	Fire Regen-Low Shrubland
SWSP	0.03 ±0.07(5)	83.47	2.73	Fire Regen-Low Shrubland
BOCH	0.03 ±0.05(3)	77.74	2.12	White Spruce
WETA	0.03 ±0.05(3)	77.74	2.12	White Spruce
YBSA	0.03 ±0.05(3)	77.74	2.12	White Spruce
CORE	0.02 ±0.04(5)	83.47	1.36	Fire Regen-Low Shrubland
HAWO	0.02 ±0.04(5)	83.47	1.36	Fire Regen-Low Shrubland
STGR	0.02 ±0.04(5)	83.47	1.36	Fire Regen-Low Shrubland
TRSW	0.02 ±0.04(5)	83.47	1.36	Fire Regen-Low Shrubland
WISN	0.02 ±0.04(5)	83.47	1.36	Fire Regen-Low Shrubland

APPENDIX 6: Number of "off grid" bird observations not counted in bird density estimates for 2004 spot mapping plots near Fort Simpson, NT.

Bird Species	Black Spruce-Open	Deciduous	Jack Pine	Low Shrubland	White Spruce
ALFL	4				
AMRE		1			
AMRO	2		2		
BAWW	1				1
BBWO			2		
BHVI	3				1
BOCH	2				1
CHSP	4				
CMWA	1				
COYE				2	
DEJU			2		
FOSP	1				
GRJA		8	1		1
HAWO					1
HETH	2		1		
LCSP				2	
LEFL		9			
LEYE	1				
LISP	4			1	
MAGW	2		2		
NHOW	1				
NOFL	2			1	1
NOWA	1			1	
NSTS				1	
OSFL	2			1	
OVEN			2		2
PAWA	5				
PIGR	1				
PIWO					1
PUFI	1				1
RBNU	3				
RCKI	3			1	
REVI		2			1
RUBL	1				
RWBL				1	
SACR	1			1	
SORA				1	
SOSA	1			1	
SWSP	2			3	
SWTH	2	2	1		3
TEWA	12	9	2		2

Bird Species	Black Spruce-Open	Deciduous	Jack Pine	Low Shrubland	White Spruce
VATH					1
WAVI		1			1
WETA	1				
WISN	1				
WIWA				1	
WTSP	4	1			1
WWPE				1	1
YBFL	2				
YBSA	1				
YRWA	1		2	2	1

APPENDIX 7: Number of "off grid" bird observations not counted in bird density estimates for 2004 spot mapping plots near Norman Wells, NT.

Bird Species	Black Spruce-Open	Fire regenerating-Low Shrubland	Deciduous	White Spruce
ALFL			2	
AMRO			3	2
BOCH				1
BOWX	1	1		
BPLW				1
CCSP			2	
CHSP	1		1	1
CORE			4	
DEJU	3		2	1
FOSP			2	
GGOW			1	
GRJA		1		1
HAWO			1	1
HETH		1	2	
LEYE				1
LISP			7	
MAGW		1		
NOFL	1	1		3
NOWA			1	
OCWA		4	2	1
OSFL				1
OVEN		1		
PAWA	3		1	
PIGR	1	1		2
PISI				1
RCKI	2	1		2
REVI		1		
RUBL			2	
RUGR				1
RWBL			1	
SACR	1			
SAVS			10	
STGR			1	
SWSP			1	
SWTH	6	1		9
TESW			1	
TEWA	1			2
VATH		1		
WAVI				1
WCSP			6	

Bird Species	Black Spruce-Open	Fire regenerating-Low Shrubland	Deciduous	White Spruce
WISN			2	
WTSP		1	1	1
WWCR	1			1
WWPE			1	1
YBFL	1			
YBSA		1		
YRWA	1	1	1	
YWAR			3	

APPENDIX 8: Number of "flyover" bird observations not counted in bird density estimates for 2004 spot mapping plots near Fort Simpson, NT.

Bird Species	Black Spruce-Open	Jack Pine	Low Shrubland	White Spruce
BAEA			1	
BOGU	1			
BOWX	3		1	1
CAGO	2			
CONI	3		1	
CORA	1		1	1
LEYE	1		1	
MEGU	1			
PISI		2	1	1
SACR	1			
TESW			1	
WISN	1		1	
WWCR	4	2	1	1

APPENDIX 8: Number of "flyover" bird observations not counted in bird density estimates for 2004 spot mapping plots near Norman Wells, NT.

Bird Species	Black Spruce-Open	Fire regenerating-Low Shrubland	Deciduous	White Spruce
CHSP	6			
CLSW		1		
CORE	1		1	3
NOFL		1		
PAWA	4			
RUBL		1		1
SACR		2		
TRSW		3		1
WWCR		1		1
YRWA		1		

APPENDIX 9: Densities of birds by habitat type as censused during 1973 surveys of the Mackenzie River Valley (Tull et al. 1974).

	Evergreen Steppe Forest	Closed Evergreen Scrub		Closed mixed Scrub		Closed Deciduous Scrub	Open Spruce Muskeg		Open Mixed Forest	Open Evergreen Scrub		Open Krummholz	Open Mixed Scrub	Open Krummholz-	Open Deciduous Scrub	Open Deciduous Scrub		Open Dec. Dwarf Scrub	Open Evergreen Dwarf Scrub-	Cl. Broad-leaved Herb. Veg.	Open Evergrn. Dwarf Scrb.- Krummholz	Evergreen Savannah	Scattered Spruce-Lichen Muskeg		Spruce Sphagnum Muskeg		Scattered Spruce-Lichen	and Sphagnum Muskeg	Evergreen Shrub Savannah	Deciduous Shrub Savannah		Scattered Mixed Scrub Savannah		Sphagnum Bog	Closed Broad-leaved Herb. Tundra	Dry Sedge Closed Herb. Tundra	Dwarf Scrub	Closed Dec.Dwarf Scrub Herb.Tundra
	C	S	C	S	C	C	S	C	C	S	C	C	C	S	C	C	N	C	C	N	C	C	S	C	S	C	S	C	C	C	N	C	N	C	N	N	N	N
Arctic Loon																													<0.5						1.6			
White-fronted Goose																																				<0.5		
Pintail																																				<0.5		
Greater Scaup																											<0.5											
Scaup spp.																				<0.5																		
Oldsquaw																																				<0.5		
White-winged Scoter												<0.5														<0.5												
Red-breasted Merganser																												<0.5										
Black Duck																												<0.5										
Bald Eagle											<0.5																											
American Kestrel															<0.5																							
Willow Ptarmigan																																			1.6	<0.5		
Whimbrel																																				<0.5		1.6
Lesser Yellowlegs											1.1	0.5			<0.5						1.6			<0.5		<0.5	<0.5	<0.5										
Spotted Sandpiper															<0.5																							
Least Sandpiper											<0.5	<0.5						<0.5																1.6				
Long-tailed Jaeger																																				<0.5		
Common Snipe		<0.5											<0.5																									
Northern Phalarope																					1.6																	
Mew Gull																0.5																						
Bonaparte's Gull											<0.5																	<0.5										
Arctic Tern																																						4.4
Common Flicker								<0.5																		<0.5												
Gray Jay	6	1.6		4.4	0	2.2	1.1			<0.5	<0.5		<0.5	<0.5	1.1	<0.5			<0.5	<0.5					<0.5	<0.5	1.1	0.5	<0.5			0.5						
Ruby-crowned Kinglet		0.5																																				
Varied Thrush		<0.5											0.5																									
Swainson's Thrush						<0.5	<0.5	1.1					1.1			1.1							0.5															
American Robin		<0.6									<0.5			<0.5										<0.5			<0.5	<0.5										
Gray-cheeked Thrush			2.7			<0.5					<0.5	<0.5	1.1			<0.5								1.1		<0.5	<0.5	<0.5										
Bohemian Waxwing						0.5	<0.5				0.5	0.5		0.5										<0.5		<0.5		<0.5										
Tennessee Warbler																<0.5																						
Orange-crowned Warbler																0.5														1.6								
Yellow Warbler																				<0.5							<0.5				<0.5				1.6	<0.5		
Yellow-rumped Warbler		1.1		1.1							1.1		<0.5	<0.5									2.2	<0.5		0.5		<0.5	<0.5									
Blackpoll Warbler			1.6				1.1		6	<0.5	<0.5	<0.5			<0.5	<0.5	0	<0.5	<0.5						<0.5	<0.5	<0.5	<0.5	1.1		<0.5							
Wilson's Warbler						0.5																																
Northern Waterthrush																							0.5															
Rusty Blackbird																			<0.5				1.6				<0.5	0.5								<0.5		
Pine Grosbeak			1.6																																			
Common Redpoll		0.5							6											0.5																<0.5		
Hoary Redpoll																															<0.5							
Redpoll sp.		1.1	2.7		6	<0.5	<0.5	1.1			0.5	<0.5	<0.5		2.2	1.6	2.7		<0.5			0	0.5	1.1	0	0.5	0.5	1.6	1.1		2.7	0.5	6	1.6		1.1		1.6
Crossbill spp.		<0.5																	<0.5																			
Savannah Sparrow													<0.5					2.2		<0.5							<0.5		<0.5							1.1		
Dark-eyed Junco	3.3	3.8				1.1	0	1.1			<0.5		0.5		<0.5	0.5									0.5	<0.5	<0.5	<0.5										
Tree Sparrow			1.6						6		2.2	2.2	<0.5		0.5		2.7	2.2	1.1	2.7		12	0	2.7	0	1.6		2.2	2.7		2.2	4.9	12			1.1	1.6	1.6
Chipping Sparrow							<0.5																					<0.5										
Harris' Sparrow											<0.5	<0.5						<0.5		<0.5									<0.5		1.1							
White-crowned Sparrow				1.6		2.7					<0.5					0.5			1.1	<0.5					<0.5	<0.5	<0.5	<0.5				2.2			1.6	0.5		
Fox Sparrow						0.5					<0.5				<0.5	0	2.7		<0.5	<0.5											1.1	0.5						
Lincoln's Sparrow						<0.5					<0.5																<0.5											
White-throated Sparrow			1.6																																			
Sparrow spp.																							0.5															
White-winged Crossbill																			<0.5								0.5	<0.5										
Lapland Longspur																																				2.7		7.7
Smith's Longspur												<0.5								<0.5											1.1							

Surveys were conducted as far north as Tuktoyaktuk to as far south as Norman Wells. Results are broken down by three latitudinal categories, where north (N) captures two sampling sites near Inuvik and Richards Island, central (C) captures six survey sites between Inuvik and Ontaratus River, and south (S) captures 2 sites near Fort Good Hope and Norman Wells. All densities have been calculated as number of birds per hectare.

APPENDIX 10: Densities of birds by habitat type as censnsed during 1974 surveys along the northern Mackenzie Valley (Ward 1975).

	Open Evergreen Forest		Open Spruce Muskeg		Scattered Spruce-Lichen Muskeg		Scattered Spruce-Moss Muskeg		Scattered Spruce-Moss Lichen Muskeg		Closed Deciduous Scrub		Open Evergreen Scrub		Open Deciduous Scrub		Open Mixed Scrub		Scattered Evergreen Scrub		Scattered Deciduous Scrub	
	S	A	S	A	S	A	S	A	S	A	S	A	S	A	S	A	S	A	S	A	S	A
Willow Ptarmigan															0.54	0.54					0.48	0.48
Lesser Yellowlegs	0.00	0.48			0.12	0.36	0.30	0.72	0.78	0.77			0.00	0.36					0.00	0.83		
Least Sandpiper																			0.42	0.42		
Gray Jay	0.72	0.72	0.77	0.77			0.18	0.42	0.45	0.89												
Bohemian Waxwing					0.24	0.42			0.00	0.36												
Yellow-rumped warbler									0.00	0.36												
Blackpoll Warbler					0.48	0.48			0.00	0.48												
Palm Warbler											0.24	0.48										
Rusty Blackbird					0.24	0.72	0.48	0.66	0.71	0.77											0.00	0.48
Hoary Redpoll															0.36	1.25						
Common Redpoll	0.00	0.95	0.24	1.31	0.30	0.83	0.18	1.07	1.17	0.60	0.48	1.79	0.06	0.42	0.18	0.36			0.00	1.01		
Redpoll sp.	0.00	0.48			0.06	0.66			0.00	1.37			0.00	0.36	0.00	0.89	0.00	0.77	0.00	0.42	0.00	0.95
Savannah Sparrow											0.48	0.48			1.61	1.61					0.00	0.66
Dark-eyed Junco	0.48	0.48							0.00	0.48	0.00	0.00					0.48	0.48			0.00	0.00
Tree Sparrow					0.66	0.72	0.48	0.72	0.78	0.89	1.13	2.26	0.48	0.60	1.61	1.97	1.19	1.67	0.42	0.42	0.66	1.13
Harris' Sparrow															0.36	0.36						
White-crowned Sparrow																					0.95	1.13
Lapland Longspur															0.89	1.07						

Ten sites to the north of Norman Wells were considered the northern part of the Mackenzie Valley. For each habitat, results are presented in two behavioural categories, sitting (S) and all behaviours (A). 'Sitting' birds were stationary when detected on transect. These birds are also captured in the "all behaviours" category which also includes flying birds in the transect area.

APPENDIX 11: Densities of birds by habitat type as censused during 1974 surveys along the southern Mackenzie Valley (Ward 1975).

	Closed Evergreen Forest		Open Evergreen Forest		Closed Deciduous Forest		Open Decidous Forest		Closed Mixed Forest		Open Mixed Forest		Open Spruce Muskeg		Scattered Spruce-Lichen Muskeg		Scattered Spruce-Moss Muskeg		Scattered Spruce-Moss Lichen Muskeg		Closed Evergreen Scrub with Scattered Trees		Closed Deciduous Scrub with Scattered Trees		Closed Mixed Scrub with Scattered Trees	
	S	A	S	A	S	A	S	A	S	A	S	A	S	A	S	A	S	A	S	A	S	A	S	A	S	A
Sharp-tailed Grouse																									0.48	0.48
Flycatcher sp.					0.42	0.42																				
Gray Jay			1.20	2.09							0.72	0.78	0.30	0.54							0.48	0.48			0.48	0.48
Varied Thrush																							0.36	0.36		
Swainson's Thrush			0.48	0.60					0.00	0.60															0.48	0.48
Ruby-crowned Kinglet			0.60	0.60																						
Red-eyed Vireo					0.42	0.42																				
Black and White Warbler					0.42	0.42	0.60	0.60																		
Tennesee Warbler			0.60	0.60	0.84	1.67	0.42	0.42			0.72	1.08														
Yellow-rumped Warbler					0.42	0.42	0.84	0.84	0.42	0.72	0.72	0.78	0.30	0.42	0.00	0.54									0.00	0.48
Blackpoll Warbler									0.48	0.48											0.48	0.48				
Rose-breasted Grosbeak					0.42	0.42																				
Common Redpoll	0.00	0.42																			0.00	0.66				
Pine Siskin	0.00	0.48	0.00	0.60			0.00	1.02					0.00	0.36	0.00	1.20					0.00	0.72	0.00	1.14		
Dark-eyed Junco			0.12	0.36							0.18	0.42			0.42	0.84			0.30	0.42			0.18	0.36		
Chipping Sparrow	0.18	0.48	0.60	0.72					0.42	0.48	0.42	0.60	0.48	0.90			0.48	0.72	0.42	0.54						

Fourteen survey sites near or south of Norman Wells were considered the southern part of the Mackenzie Valley. For each habitat, results are presented in two behavioural categories, sitting (S) and all behaviours (A). 'Sitting' birds were stationary when detected on transect. These birds are also captured in the "all behaviours" category which also includes flying birds in the transect area.

APPENDIX 12: Densities of birds by habitat type as censused during 1975 surveys along the northern Mackenzie Valley (Patterson et al. 1977).

	Closed Evergreen Forest		Open Evergreen Forest		Closed Deciduous Forest		Open Decidous Forest		Closed Mixed Forest		Open Mixed Forest		Open Spruce Muskeg		Scattered Spruce-Lichen Muskeg		Scattered Spruce-Moss Muskeg		Scattered Spruce-Moss Lichen Muskeg		Closed Evergreen Scrub with Scattered Trees		Closed Deciduous Scrub with Scattered Trees		Closed Mixed Scrub with Scattered Trees	
	S	A	S	A	S	A	S	A	S	A	S	A	S	A	S	A	S	A	S	A	S	A	S	A	S	A
Sharp-tailed Grouse																									0.48	0.48
Flycatcher sp.					0.42	0.42																				
Gray Jay			1.20	2.09							0.72	0.78	0.30	0.54							0.48	0.48			0.48	0.48
Varied Thrush																							0.36	0.36		
Swainson's Thrush			0.48	0.60					0.00	0.60															0.48	0.48
Ruby-crowned Kinglet			0.60	0.60																						
Red-eyed Vireo					0.42	0.42																				
Black and White Warbler					0.42	0.42	0.60	0.60																		
Tennesee Warbler			0.60	0.60	0.84	1.67	0.42	0.42			0.72	1.08														
Yellow-rumped Warbler					0.42	0.42	0.84	0.84	0.42	0.72	0.72	0.78	0.30	0.42	0.00	0.54									0.00	0.48
Blackpoll Warbler									0.48	0.48											0.48	0.48				
Rose-breasted Grosbeak					0.42	0.42																				
Common Redpoll	0.00	0.42																			0.00	0.66				
Pine Siskin	0.00	0.48	0.00	0.60			0.00	1.02					0.00	0.36	0.00	1.20					0.00	0.72	0.00	1.14		
Dark-eyed Junco			0.12	0.36							0.18	0.42			0.42	0.84			0.30	0.42			0.18	0.36		
Chipping Sparrow	0.18	0.48	0.60	0.72					0.42	0.48	0.42	0.60	0.48	0.90			0.48	0.72	0.42	0.54						

Areas along the northern end of the gas line from Thunder River to the Mackenzie Bay were considered the northern part of the Mackenzie Valley.

APPENDIX 13: Densities of birds by habitat type as censused during 1975 surveys along the southern Mackenzie Valley (Wrigley and Tull 1977).

	Closed Evergreen Forest	Open Evergreen Forest	Closed Deciduous Forest	Open Deciduous Forest	Open Mixed Forest	Open Spruce Muskeg	Scattered Spruce-Moss Muskeg	Scattered Spruce-Moss Lichen Muskeg	Open Evergreen Scrub	Closed Deciduous Scrub	Open Deciduous Scrub	Sedge Marsh
American Wigeon								0.05				
Lesser Scaup						0.16						
White-winged Scoter								0.05				
Goshawk				0.11								
Common Snipe								*				0.44
Spotted Sandpiper							0.11					
Solitary Sandpiper								0.05				
Greater Yellowlegs									0.87			1.20
Lesser Yellowlegs								*				0.77
Yellowlegs spp.						0.44		*				
Yellow-bellied Sapsucker					0.16							
Alder Flycatcher										1.64		
Least Flycatcher		0.11			0.38							
Gray Jay	0.44	1.26		0.22		0.60	0.11	0.27				
Boreal Chickadee				0.22	0.16		0.11					
American Robin					0.16							0.44
Hermit Thrush				0.11	0.16		0.11					
Swainson's Thrush	0.82	0.60			0.38	0.16	0.11		0.00	0.87		
Thrush spp.	0.44											
Ruby-crowned Kinglet		0.22										
Solitary Vireo					0.16							
Red-eyed Vireo				0.44	0.16			*				
Vireo spp.		0.22										
Black-and-white Warbler											0.71	
Tennessee Warbler	0.44	1.26	2.02	3.61	0.82	0.60		*		0.87	1.53	
Magnolia Warbler			0.38									
Cape May Warbler		0.22										
Yellow-rumped Warbler		0.22	0.38	0.22	0.16	0.44	0.11				0.77	
Bay-breasted Warbler		0.11										
Palm Warbler	0.44					0.44		0.16		0.87		
Ovenbird				0.11								
Northern Waterthrush										0.87		
American Redstart		0.49		0.44	0.38	0.16					0.77	
Warbler spp.			0.38									
Red-winged Blackbird								0.05				
Rusty Blackbird	0.44							0.16				1.20
Common Grackle						0.16						
Blackbird spp.						0.16						
Western Tananger	0.44	0.11			0.38							
Pine Siskin											0.77	
White-winged Crossbill								0.05				
Crossbill spp.		0.22										
Savannah Sparrow								*				
Dark-eyed Junco		0.38		0.27		0.60	0.11	0.44				1.20
Chipping Sparrow	0.82	0.22		0.11	0.16	0.16	0.44	0.44		0.87		0.44
White-throated Sparrow					0.16	0.16						
Swamp Sparrow								0.05				
Lincoln's Sparrow						0.16	0.11	0.05		0.87		
Sparrow spp.		0.11										
Passerine spp.	0.82	0.11	0.98	0.66	0.16	0.44	0.11	0.55	0.87	3.55		0.44

Areas from River between Two Mountains to Bistcho Lake in northern Alberta were considered the southern part of the Mackenzie Valley.

Appendix 14: Bird species recorded for the Northwest Territories from the NWT Bird Checklist database.

Species	Status[1]
Red-throated Loon	Uncommon
Pacific Loon	Fairly common
Common Loon	Fairly common
Yellow-billed Loon	Fairly common
Pied-billed Grebe	Uncommon
Horned Grebe	Uncommon
Red-necked Grebe	Fairly common
Eared Grebe	Rare
American White Pelican	Rare
Double-crested Cormorant	Accidental
American Bittern	Rare
Great Blue Heron	Rare
Great Egret	Casual
Turkey Vulture	Casual
Greater White-fronted Goose	Very common
Snow Goose	Abundant
Canada Goose[2]	Very common
Brant	Uncommon
Trumpeter Swan	Uncommon
Tundra Swan	Common
Gadwall	Uncommon
Eurasian Wigeon	Casual
American Wigeon	Common
American Black Duck	Casual
Mallard	Common
Blue-winged Teal	Uncommon
Cinnamon Teal	Accidental
Northern Shoveler	Fairly common
Northern Pintail	Common
Green-winged Teal	Common
Canvasback	Fairly common
Redhead	Uncommon
Ring-necked Duck	Fairly common
Greater Scaup	Common
Lesser Scaup	Common
King Eider	Uncommon
Common Eider	Fairly common
Harlequin Duck	Uncommon
Surf Scoter	Common
White-winged Scoter	Common
Black Scoter	Rare
Long-tailed Duck	Common
Bufflehead	Common
Common Goldeneye	Common
Barrow's Goldeneye	Fairly common
Hooded Merganser	Rare
Common Merganser	Common
Red-breasted Merganser	Common
Ruddy Duck	Uncommon
Osprey	Uncommon
Bald Eagle	Uncommon
Northern Harrier	Uncommon
Sharp-shinned Hawk	Uncommon
Cooper's Hawk	Casual
Northern Goshawk	Uncommon
Broad-winged Hawk	Uncommon
Swainson's Hawk	Casual
Red-tailed Hawk	Uncommon
Ferruginous Hawk	Accidental
Rough-legged Hawk	Fairly common
Golden Eagle	Uncommon
American Kestrel	Fairly common
Merlin	Uncommon
Gyrfalcon	Uncommon
Peregrine Falcon	Fairly common
Ruffed Grouse	Uncommon
Spruce Grouse	Fairly common
Willow Ptarmigan	Common
Rock Ptarmigan	Fairly common
White-tailed Ptarmigan	Casual
Blue Grouse	Rare
Sharp-tailed Grouse	Uncommon
Yellow Rail	Casual
Virginia Rail	Accidental
Sora	Uncommon
American Coot	Common
Sandhill Crane	Fairly common
Whooping Crane	Casual
Black-bellied Plover	Fairly common
American Golden Plover	Fairly common
Semipalmated Plover	Fairly common
Killdeer	Uncommon
Eurasian Dotterel	Accidental
American Avocet	Rare
Greater Yellowlegs	Uncommon
Lesser Yellowlegs	Common
Solitary Sandpiper	Uncommon
Willet	Casual
Wandering Tattler	Rare
Spotted Sandpiper	Fairly common
Upland Sandpiper	Uncommon
Eskimo Curlew	Casual

Species	Status[1]
Whimbrel	Common
Hudsonian Godwit	Uncommon
Bar-tailed Godwit	Accidental
Marbled Godwit	Accidental
Ruddy Turnstone	Uncommon
Surfbird	Accidental
Red Knot	Rare
Sanderling	Uncommon
Semipalmated Sandpiper	Fairly common
Western Sandpiper	Casual
Least Sandpiper	Common
White-rumped Sandpiper	Rare
Baird's Sandpiper	Fairly common
Pectoral Sandpiper	Fairly common
Purple Sandpiper	Rare
Dunlin	Uncommon
Stilt Sandpiper	Fairly common
Buff-breasted Sandpiper	Uncommon
Ruff	Accidental
Short-billed Dowitcher	Uncommon
Long-billed Dowitcher	Uncommon
Wilson's Snipe	Uncommon
Wilson's Phalarope	Rare
Red-necked Phalarope	Common
Red Phalarope	Rare
Pomarine Jaeger	Fairly common
Parasitic Jaeger	Fairly common
Long-tailed Jaeger	Fairly common
Franklin's Gull	Uncommon
Bonaparte's Gull	Common
Mew Gull	Common
Ring-billed Gull	Fairly common
California Gull	Fairly common
Black-tailed Gull	Accidental
Herring Gull	Very common
Thayer's Gull	Uncommon
Glaucous-winged Gull	Rare
Glaucous Gull	Fairly common
Sabine's Gull	Rare
Black-legged Kittiwake	Accidental
Caspian Tern	Uncommon
Common Tern	Fairly common
Arctic Tern	Common
Black Tern	Fairly common
Slaty-backed Gull	Rare
Thick-billed Murre	Rare
Black Guillemot	Rare
Rock Dove	Casual
Mourning Dove	Rare

Species	Status[1]
Great Horned Owl	Uncommon
Snowy Owl	Uncommon
Northern Hawk Owl	Rare
Barred Owl	Casual
Great Gray Owl	Rare
Long-eared Owl	Casual
Short-eared Owl	Uncommon
Boreal Owl	Rare
Common Nighthawk	Fairly common
Calliope Hummingbird	Accidental
Rufous Hummingbird	Casual
Belted Kingfisher	Uncommon
Yellow-bellied Sapsucker	Fairly common
Downy Woodpecker	Uncommon
Hairy Woodpecker	Uncommon
Three-toed Woodpecker	Uncommon
Black-backed Woodpecker	Uncommon
Northern Flicker	Fairly common
Pileated Woodpecker	Uncommon
Olive-sided Flycatcher	Uncommon
Western Wood-Pewee	Uncommon
Yellow-bellied Flycatcher	Rare
Alder Flycatcher	Common
Least Flycatcher	Fairly common
Hammond's Flycatcher	Uncommon
Eastern Phoebe	Uncommon
Say's Phoebe	Uncommon
Eastern Kingbird	Uncommon
Northern Shrike	Rare
Blue-headed Vireo	Uncommon
Warbling Vireo	Fairly common
Philadelphia Vireo	Casual
Red-eyed Vireo	Fairly common
Gray Jay	Common
Black-billed Magpie	Fairly common
American Crow	Fairly common
Common Raven	Very common
Horned Lark	Common
Tree Swallow	Common
Violet-green Swallow	Fairly common
Bank Swallow	Common
Cliff Swallow	Common
Barn Swallow	Uncommon
Black-capped Chickadee	Fairly common
Boreal Chickadee	Fairly common
Red-breasted Nuthatch	Uncommon
Winter Wren	Uncommon
Marsh Wren	Uncommon
American Dipper	Rare

Species	Status[1]
Golden-crowned Kinglet	Casual
Ruby-crowned Kinglet	Fairly common
Northern Wheatear	Casual
Mountain Bluebird	Uncommon
Townsend's Solitaire	Uncommon
Gray-cheeked Thrush	Fairly common
Swainson's Thrush	Common
Hermit Thrush	Uncommon
American Robin	Common
Varied Thrush	Uncommon
Gray Catbird	Casual
Brown Thrasher	Accidental
European Starling	Uncommon
Yellow Wagtail	Casual
American Pipit	Very common
Sprague's Pipit	Casual
Bohemian Waxwing	Common
Cedar Waxwing	Uncommon
Tennessee Warbler	Common
Orange-crowned Warbler	Fairly common
Yellow Warbler	Fairly common
Magnolia Warbler	Fairly common
Cape May Warbler	Uncommon
Yellow-rumped Warbler	Common
Townsend's Warbler	Casual
Palm Warbler	Uncommon
Bay-breasted Warbler	Uncommon
Blackpoll Warbler	Common
Black-and-white Warbler	Fairly common
American Redstart	Fairly common
Ovenbird	Fairly common
Northern Waterthrush	Uncommon
Connecticut Warbler	Rare
Mourning Warbler	Rare
Common Yellowthroat	Uncommon
Wilson's Warbler	Uncommon
Canada Warbler	Rare
Western Tanager	Uncommon
American Tree Sparrow	Common
Chipping Sparrow	Common
Clay-colored Sparrow	Fairly common
Lark Sparrow	Accidental
Savannah Sparrow	Common
Le Conte's Sparrow	Uncommon
Sharp-tailed Sparrow	Casual
Fox Sparrow	Fairly common
Song Sparrow	Uncommon
Lincoln's Sparrow	Fairly common
Swamp Sparrow	Fairly common
White-throated Sparrow	Fairly common
Harris' Sparrow	Fairly common
White-crowned Sparrow	Common
Golden-crowned Sparrow	Uncommon
Dark-eyed Junco	Common
Lapland Longspur	Very common
Smith's Longspur	Fairly common
Snow Bunting	Common
Rose-breasted Grosbeak	Uncommon
Lazuli Bunting	Casual
Indigo Bunting	Accidental
Red-winged Blackbird	Common
Western Meadowlark	Accidental
Yellow-headed Blackbird	Rare
Rusty Blackbird	Common
Brewer's Blackbird	Fairly common
Common Grackle	Uncommon
Brown-headed Cowbird	Uncommon
Baltimore Oriole	Accidental
Gray-Crowned Rosy-Finch	Uncommon
Pine Grosbeak	Fairly common
Purple Finch	Fairly common
House Finch	Accidental
Red Crossbill	Rare
White-winged Crossbill	Common
Common Redpoll	Very common
Hoary Redpoll	Common
Pine Siskin	Common
Evening Grosbeak	Fairly common
House Sparrow	Common

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[1] Status designations follow Campbell et al. 1990. Accidental=1 record; Casual=2-6 records; Very Rare= more than 6 records but may not occur every year; Rare=occurs annually but in very small numbers; Uncommon=1-6 individuals often observed during a day; Fairly Common=7-20 individuals; Common= 21-50 individuals; Very Common= 51-200 individuals; Abundant=>200 individuals.

[2] Shading denotes species detected during 2004 spot mapping in the Mackenzie Valley.

APPENDIX 15. COMPARISON OF MEAN NUMBER OF BIRDS DETECTED ON THREE BBS ROUTES IN THE NWT.

	Norman Wells	**Fort Simpson**	**Fort Liard**			
Species	mean	mean	mean	t-test pair-wise comparisons		
				NW-FS	NW-FL	FS-FL
OSFL	0.8 ± 0.4	1.4 ± 0.5	0.1 ± 0.1	0.33187778	0.105634	0.045682
WWPE	0 ± 0	0.7 ± 0.3	1.4 ± 0.4	0.094132766	0.009535	0.238145
YBFL	0 ± 0	0.7 ± 0.3	5.3 ± 1.8 *	0.094132766	0.015112	0.030023
ALFL	21.3 ± 2.9	23.4 ± 4.3	49.8 ± 7.4 *	0.70935529	0.004084	0.009301
LEFL	0.3 ± 0.2	17.9 ± 2.7 *	21.2 ± 2.6 *	0.000997059	1.91E-05	0.409188
EAPH	0 ± 0	1.4 ± 0.5	0.6 ± 0.3	0.035339786	0.111373	0.214449
EAKI	0.3 ± 0.2	0.3 ± 0.2	0 ± 0	0.850998275	0.080516	0.172308
BHVI	0 ± 0	3.9 ± 1.1 *	1.6 ± 0.6 *	0.016102019	0.019143	0.11533
WAVI	0.6 ± 0.3	17.3 ± 1.4 *	15.2 ± 1.5 *	1.62745E-05	3.15E-06	0.341836
REVI	0.4 ± 0.2	29.6 ± 1.5	36.8 ± 2.5 *	1.48502E-06	1.19E-07	0.028904
GRJA	11.2 ± 1.7	13.7 ± 2.8	8.4 ± 1.5	0.488279019	0.243019	0.147999
AMCR	0 ± 0	0.1 ± 0.1	0.1 ± 0.1	0.355917684	0.343436	0.810198
CORA	0.7 ± 0.3	2.6 ± 0.5 *	0.9 ± 0.4	0.015545291	0.630593	0.0329
TRES	1.1 ± 0.6	3 ± 0.8	0.9 ± 0.3	0.099319112	0.765781	0.048795
BARS	0 ± 0	1.3 ± 0.3	2.8 ± 1.3	0.011695964	0.066229	0.300025
BCCH	0 ± 0	0 ± 0	1.4 ± 0.4	na	0.009535	0.009535
BOCH	0.8 ± 0.3	0.4 ± 0.2	0.7 ± 0.3	0.327026456	0.840583	0.423062
RBNU	0 ± 0	0.7 ± 0.3	3.2 ± 1.0 *	0.046528232	0.012623	0.041665
RCKI	12.1 ± 2.5 *	17.9 ± 1.6 *	5.1 ± 1.4	0.084522014	0.031835	9.01E-05
SWTH	69 ± 5.4	58.9 ± 3.4	59.8 ± 3.8	0.142773257	0.182384	0.860495
HETH	16.6 ± 3.6 *	11.7 ± 1.5 *	4.7 ± 1.0	0.247450013	0.011432	0.003517
AMRO	32.4 ± 2.6 *	18.7 ± 3.6	14.3 ± 2.6	0.013965379	0.00015	0.368319
VATH	1.7 ± 0.5	0.1 ± 0.1	1.3 ± 1.0	0.020708312	0.748583	0.275694
BOWA	0.7 ± 0.4	3.4 ± 1.3	0.5 ± 0.3	0.101431763	0.721894	0.084514
TEWA	3 ± 1.4	83.4 ± 11.1 *	94.2 ± 10.8 *	0.000482921	1.26E-05	0.514769
OCWA	17.9 ± 3.1 *	1.9 ± 0.9	0.6 ± 0.2	0.000657808	0.000502	0.265908
YWAR	3.9 ± 1.1 *	0.3 ± 0.3	0.8 ± 0.2	0.011187756	0.023178	0.197478
MAGW	0.8 ± 0.4	28.3 ± 2.7	40.3 ± 3.6 *	6.57616E-05	1.63E-06	0.020796
CMWA	0 ± 0	3.9 ± 1.6	1.2 ± 0.6	0.06497286	0.088746	0.184654
YRWA	36.8 ± 6.0 *	44.9 ± 3.7 *	18 ± 2.7	0.281586253	0.015168	0.000169
PAWA	8.6 ± 2.9 *	1.7 ± 1.0	1.2 ± 0.5	0.04962285	0.03446	0.677619
BPWA	8.2 ± 1.0 *	2.3 ± 1.0	0.6 ± 0.4	0.001613676	2.18E-05	0.198898
BAWW	0 ± 0	5.6 ± 1.9 *	7.9 ± 2.2 *	0.034464868	0.006185	0.452981
AMRE	0 ± 0	5.3 ± 2.0	21.6 ± 2.6 *	0.049764739	1.45E-05	0.000204
OVEN	0 ± 0	20.6 ± 3.0	30.7 ± 3.0 *	0.000701708	3.17E-06	0.038156
NOWA	0.6 ± 0.3	5.1 ± 1.2 *	7 ± 1.4 *	0.011009227	0.001141	0.341648
COYE	1.6 ± 0.4	3.3 ± 0.6	2 ± 0.5	0.054162445	0.487453	0.147578
CAWA	0 ± 0	0.1 ± 0.1	1.7 ± 0.7	0.355917684	0.041546	0.059471
WETA	0.2 ± 0.2	12.1 ± 2.8 *	10.4 ± 1.5 *	0.008120701	8.01E-05	0.623658
ATSP	0 ± 0	0.1 ± 0.1	0.6 ± 0.6	0.355917684	0.343436	0.475624
CHSP	37.9 ± 1.8	42.9 ± 2.6	36.2 ± 4.8	0.162990887	0.747857	0.250419
CCSP	0.1 ± 0.1	0 ± 0	0.3 ± 0.2	0.346593507	0.446089	0.193422

LESP	0 ± 0	0.1 ± 0.1	0.3 ± 0.3	0.355917684	0.343436	0.644369
FOSP	10.4 ± 2.3	3.4 ± 0.7	17 ± 1.9	0.016751728	0.04305	2.6E-05
SOSP	0 ± 0	0.1 ± 0.1	0.1 ± 0.1	0.355917684	0.343436	0.810198
LISP	24.7 ± 2.5 *	5.9 ± 0.9	14.4 ± 1.9	3.31908E-05	0.005434	0.001742
SWSP	5.1 ± 1.1 *	1.7 ± 0.4	2.2 ± 0.6	0.019144082	0.043624	0.546647
WTSP	10.2 ± 1.7	23.1 ± 4.1	46.4 ± 2.4 *	0.028170276	2.15E-09	0.001191
DEJU	19.8 ± 3.6	13.1 ± 2.7	8.9 ± 1.7	0.179887523	0.019803	0.241032
RBGR	0 ± 0	0.7 ± 0.3	9.8 ± 1.6 *	0.094132766	0.00022	0.00033
RWBL	0.6 ± 0.2	6.4 ± 1.3 *	0.3 ± 0.2	0.006302109	0.387491	0.005309
WWCR	6.9 ± 3.7	38 ± 23.0	6.3 ± 2.8	0.259809354	0.900898	0.250685
CORE	3.8 ± 1.0	2.6 ± 2.2	2.5 ± 2.1	0.655235211	0.587078	0.9824
PISI	0.1 ± 0.1	2.7 ± 1.1	9.9 ± 5.1	0.07866388	0.085113	0.197591

APPENDIX 16. BOREAL BIRD SPECIES WITH DECLINING POPULATION TRENDS AS INDICATED BY BREEDING BIRD SURVEYS (MODIFIED FROM BLANCHER 2003).

Declining Species	Global Population Breeding in Boreal (%)	BBS Population Trend[1]	Canada BBS Population Trend (1968-2002)[2]
Neotropical migrants			
Connecticut Warbler	92	-8.9[b]	-1.7
Mourning Warbler	75	-1.2[a]	-2.7*
Least Flycatcher	65	-0.9[a]	-0.3
Blackpoll Warbler	65	-3.7[b]	-5.6*
Canada Warbler	64	-6.2[b]	-4.3*
Swainson's Thrush	59	-0.5[b]	-0.8*
Clay-colored Sparrow	51	-1.4[a]	0.2
Chestnut-sided Warbler	46	-1.6[b]	-2.0*
Olive-sided Flycatcher	38	-3.3[b]	-3.5*
Gray-cheeked Thrush	35	-8.8[b]	-11.5
Wilson's Warbler	31	-1.0[c]	-3.0*
Common Yellowthroat	26	-0.3[c]	-0.6*
Western Wood-Pewee	19	-2.7[b]	1.5
Baltimore Oriole	12	-0.9[a]	-0.7
Common Nighthawk	6	-7.4[b]	-3.9*
Bank Swallow	6	-6.3[b]	-4.7*
Eastern Kingbird	4	-1.3[a]	-1.8*
Bobolink	4	-2.8[b]	-4.5*
Barn Swallow	2	-2.8[b]	-2.9*
Short-distance migrants			
White-throated Sparrow	85	-0.7[a]	-1.3*
Rusty Blackbird	70	-14.7[b]	-10.3*
Dark-eyed Junco	66	-1.6[a]	-1.2*
White-crowned Sparrow	48	-1.6[c]	2.0
Purple Finch	47	-4.2[b]	-3.4*
Pine Siskin	46	-2.6[b]	-0.2
Belted Kingfisher	38	-2.0[a]	-2.1*
Northern Flicker	31	-1.1[a]	-1.3*
Song Sparrow	20	-1.1[a]	-1.6*
American Kestrel	18	-1.2[a]	-1.0
Vesper Sparrow	10	-0.9[c]	-0.9
Red-winged Blackbird	6	-1.1[a]	-1.6*
Northern Harrier	5	-4.6[b]	-2.0*
Brown-headed Cowbird	5	-2.3[a]	-2.8*
European Starling	2	-2.1[b]	-3.2*
Western Meadowlark	1	-2.2[a]	-2.2*
Horned Lark	1	-3.4[a]	-4.9*
Resident species			
Boreal Chickadee	78	-2.9[a]	-3.2*
Gray Jay	73	-3.4[b]	0.1
Great Horned Owl	6	-5.6[b]	-0.7
House Sparrow	<1	-2.6[a]	-3.6*

[1] Breeding Bird Survey Trend in Canada or North America showing **largest declining trend**

[2] Canadian BBS trend from Canadian Wildlife Service web site (1968-2002). * shows P is significant

[a] Canadian BBS trend from Sauer et al. 2002 (1966-2001)

[b] Canadian BBS trend from Canadian Wildlife Service web site (1967-2000)

[c] North American BBS trend from Sauer et al. 2002 (1966-2001)

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